RESEARCH THESIS TITLE

A COMPREHENSIVE STANDARDS-BASED FRAMEWORK FOR ENABLING SEMANTIC INTEROPERABILITY OF DISEASE SURVEILLANCE DATA FOR NAMIBIA THROUGH ADOPTING HEALTH STANDARDS

by

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- Angula, N., & Dlodlo, N. (2018). Enabling semantic interoperability of disease surveillance data in heterogeneous health information systems in Namibia as a standard approach. 16th International Conference on eSociety 2018. Lisbon, Portugal, 281-288**.**
- Angula, N., & Dlodlo, N. (2018). Towards a framework to enable semantic interoperability of data in heterogeneous health information systems in Namibian public hospitals. Proceedings of the 2018 International Conference on Information Technology and Systems ICITS 2018. Peninsula de Santa Elena, Ecuador, 1167-1168.
- Angula, N., & Dlodlo, N., Mtshali, P. Q. (2019). Enabling semantic interoperability of crowd-sourced disease surveillance data for Namibia through a health-standards-based approach. IST Africa 2019. Kenya, Nairobi, 34-35.
- Angula, N., & Dlodlo, N. (2018). Towards the development of an interlink protocol for disease surveillance data aggregation: a Namibian context. International Conference on Intelligent and Innovative Computing Applications (ICONIC) 2018. Mauritius, 73-79.
- Angula, N., & Dlodlo, N. (2018). Enabling semantic interoperability of disease surveillance data in health information exchange systems for community health workers. International Conference on Applied Informatics**.** Research Center in Informatics and Information Technology. "Lucian Blaga" University of Sibiu, 281-288.
- Angula, N., & Dlodlo, N. (2018). A framework to enable semantic interoperability of data in heterogeneous health information systems: A case of Namibia. Springer International Publishing. Euguado. Ecuador, 835-845.

Declaration

I, Nikodemus Angula, hereby declare that the work contained in the thesis for the PhD in Information Technology project, entitled: "A comprehensive standards-based framework for enabling semantic interoperability of disease surveillance data for Namibia through adopting health standards" is my original work and that I have not previously in its entirety or part submitted it to any university or other higher education institution for the award of a degree. I further declare that I fully acknowledged all sources of information I have used for the research following the institution's rules.

SIGNATURE OF THE MAIN SUPERVISOR

I, _NomusaDlodlo, herewith declare that I accepted this thesis for my supervision.

Signature: _________ ___________________ Date: _____________________02/09/2021

SIGNATURE OF THE CO- SUPERVISOR

I, Progress Mtshali________________________, herewith declare that I accepted this thesis for my supervision.

Signature: ________ Date: _ 02/09/2021_______

SIGNATURE OF THE STUDENT

Signature: ___________ ______________ Date: ___02/09/2021___

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List of Acronyms

EUA - Enterprise user authentication
ICTs - Information and communication technologies
ODD - On-demand documents
PIX - Patient identifier cross-referencing
PSA - The patient synchronised application
RFD - Retrieve form for data capture
RID - Retrieve information for display
SVS - Sharing value sets
XCA - Cross community access
XDM - Cross enterprise document media interchange
XDR - Cross enterprise document reliable interchange
XDS - Cross-enterprise document sharing
XPCD - Cross community patient discovery
XUA - Cross enterprise user assertion profile
ARPANET - Advanced research projects agency network
CDC - Centre for disease control
CSMA/CD - Carrier sense multiple access collision detection
DHIS - 2 - District health information system
DPs - Development partners
DSP - Directorate of special programmes
EHRs - Electronic health records
EPM - Expanded programmes on immunisation
FEA - Federal enterprise architecture
FTP - File transfer protocol
GDP - Gross domestic product
HIM - Health information management
HIMSS - Healthcare information and management systems society
HIS - Health information system
HL7 - Health level seven
HLA - High level architecture
HTML - Hypertext markup language

HTTP	- The hypertext transfer protocol
IHE	- Integrating the healthcare enterprise
ILP	- Interlink protocol
IP	- Internet protocol
IT	- Information technology
JSON	- Javascript object notation
MCS	- Mobile crowdsourcing
MoHSS	- The Ministry of Health and Social Services
NHIS	- Namibia’s national health information system
OSI	- The open system interconnection
PDQ	- Patient demographics query
PIX	- Patient identifier cross-referencing
PMI	- The patient master index
PSA	- Patient synchronised applications
SDOs	-Standards development organisations
SMTP	- Simple mail transfer protocol
SNMP	- Simple network management protocol
UHC	- Universal health coverage
UTAUT	- Unified theory of acceptance and use of technology
WHO	- World health organisation
XML	- Extensible markup language

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Preliminaries or Basic Concepts

Community health worker (CHW) – Community health workers are members of a community who are chosen by the community or organisations to provide basic health and medical care to their community. They are capable of providing preventive, emotional and rehabilitation care to these communities.

Crowd-sourcing is a sourcing model in which individuals or organisations obtain goods and services through dividing work between participants to achieve a cumulative result. These services include ideas and finances, from a large, relatively open and often rapidly-evolving group of internet users.

Disease surveillance is an information-based activity involving the collection, analysis and interpretation of large volumes of data originating from a variety of sources. The information collated is then used in several ways to evaluate the effectiveness of control and preventative health measures.

Health Level 7 or **HL7** refers to a set of international standards for the transfer of clinical and administrative data between software applications used by various healthcare providers.

Integrating the Healthcare Enterprise (**IHE**) is a non-profit organisation based in the US state of Illinois. It sponsors an initiative by the healthcare industry to improve the way computer systems share information. IHE was established in 1998 by a consortium of radiologists and information technology (IT) experts.

Interoperability is a characteristic of a product or system, whose interfaces are completely understood, to work with other products or systems, at present or in the future, in either implementation or access, without any restrictions.

Semantic interoperability is the ability of computer systems to exchange data with unambiguous, shared meaning. Semantic interoperability is a requirement to enable machine computable logic, inferencing, knowledge discovery, and data federation between information systems.

The Patient Master index (PMI) is the TriMed medical database that holds information on every patient registered at a healthcare organisation.

Abstract

The Ministry of Health and Social Services (MoHSS) in Namibia runs silo information systems in the 14 regions of the country, and these silo systems were donated by non-governmental organisations. In addition to a regional District Health Information System (DHIS-2) for each region, there is the main DHIS-2 at the MoHSS. The Health Information Systems (HIS) that include the main DHIS-2 at the MoHSS and silo systems in the regions work in isolation currently. Hence this study aimed at finding a framework to enable semantic interoperability of disease surveillance data in these HIS. This is meant to enable the main DHIS-2 and these silo systems in the Namibian public hospitals to act as an integrated platform that shares and exchanges disease-surveillance information. Semantic interoperability is the ability to automatically interpret the information exchanged meaningfully and accurately to produce useful results as defined by the end users of both systems. To achieve semantic interoperability, both sides must defer to a common information exchange reference. Utilising the Integrating the Healthcare Enterprise (IHE) standard and Health Level Seven (HL7), this research provides guidelines on how to integrate these heterogeneous HIS through the adoption of established health standards. Thus, IHE and HL7 standards were adopted to interface the main DHIS-2 and silo systems at a data level. The result of this research is a framework to enable the semantic interoperability of disease surveillance data in Namibian public hospitals through the adoption of IHE and HL7 standards, in addition to a prototype that demonstrates how disease surveillance data can be integrated in the Namibia healthcare environment.

In the Namibian health domain, there is no known protocol that governs or aggregates disease surveillance data from remote heterogeneous HIS. Therefore, the study developed an interlink protocol that can aggregate disease surveillance data from remote HIS. This means that health professionals in Namibia would use the system for fast decision-making simply because they are accessing disease surveillance data in real-time. In this case, the protocol was applied to govern heterogeneous systems in Namibian public hospitals for data semantic interoperability of the main DHIS-2 and these other health information silo systems so that they can exchange health data and information, specifically, disease surveillance data. This interlink protocol is based on JSon.

To test the Interlink protocol, a number of use case scenarios were used. The scenarios include integrating crowd-sourced disease surveillance data through the communities' mobile phones, integrating disease surveillance data collected through community health workers' (CWH) visits, and also integrating disease surveillance data collected from community members during hospital visits. In each case, the interlink protocol is paired to an HL7 standard to facilitate communication of the disease surveillance data from the source to the integrated HIS. A prototype for each use case is developed as proof of concept, to test that the protocol can enable integration of the disease surveillance data in these HIS. The Retrieval Display profile was identified from HL7 standards as the closest to suit the integration of disease surveillance information obtained through mobile crowdsourcing. The Cross-Gateway Patient Discovery (XCPD) profile that supports the means to locate communities that hold patient-relevant health data and the translation of patient identifiers across communities holding the same patient data was adapted to support communication between CHWs, the DHIS-2 in the MoHSS and silo HIS in the regional hospitals. The Patient Demographics Actor (PDA) profile was adapted to support communication for data collected within the hospitals.

The research was conducted in two phases. The first phase was the collection of data on the status of semantic interoperability of HIS in the Namibian healthcare sector. The case study setting was based on public hospitals from eight regions in Namibia using two (2) public hospitals per region, which were purposely sampled. The study population comprised of system analysts, programmers, chief system administrators, system administrators, disease surveillance office, chief disease surveillance office nurses, doctors, therapists, health assistants, public health officers, health administrators, regional health coordinators and regional assistant coordinators. A stratified purposive sampling of the study participants was done. This first phase followed an interpretive approach. This first phase supported a mixed methods approach encompassing both qualitative and quantitative data analyses. The Grounded Theory was the underlying theory of this research. The second phase was the design and development of the semantic interoperability framework. The Design Science Research (DSR) approach guided the development of the framework and prototype. Expert reviews were sought to review and validate the framework and prototype that were developed.

The study contributions to the body of knowledge were that the researcher has proven silo HIS in Namibia can be integrated, developed a prototype, integrating health standards to Namibia which hasn’t been done before.

CHAPTER 1: INTRODUCTION

This chapter provides an overview of the introduction to the study and the problem statement. It also provides the research objectives, ethical considerations, the limitations of the study, research significance, and the aims of the study, including the conclusion.

1.1 Introduction

In the Namibian health sector, information silo systems in the 14 regions of Namibia came about as a result of donations by non-governmental organisations. This is in addition to a regional district health information system (DHIS-2) for each of the regions and the main DHIS-2 that is housed at the MoHSS (Angula & Dlodlo, 2018). In this heterogeneous environment, it is necessary to enable semantic interoperability of disease surveillance data of these health information systems (HIS) so that the main DHIS-2 and these silo systems in the Namibian public hospitals can act as an integrated platform to share and exchange health-related information. Semantic interoperability is the ability to automatically interpret the exchanged information meaningfully and accurately to produce useful results as defined by the end users of both systems (Association, 2011). Both sides must defer to a common information exchange reference to achieve semantic interoperability of disease surveillance data. The research follows three case studies which are a crowdsourcing case study, a community health workers (CHW) case study, and a hospital to hospital case study, to test that an interlink protocol developed for enabling disease surveillance data aggregation in heterogeneous health information developed in the study is applicable.

With disease surveillance as a case study, this study sought to interface the main DHIS-2 at the MoHSS and the rest of the silo systems at a semantic (data) level through the integrating the health enterprise (IHE) and health level seven (HL7) standards. IHE is a consortium that advocates the sharing of information from distributed and heterogeneous HIS (Siegel, 2001). HL7, on the other hand, is an ANSI-accredited XML-based messaging standard that provides a framework and related standards for the exchange, integration, sharing and retrieval of electronic health information that supports clinical practice and the management, delivery and evaluation of health services. Integrating HIS in Namibia would be done through standards that specify protocols through which integrated systems could communicate as profiles. The Namibian healthcare sector has not taken advantage of these standards as yet. In this study, a framework that utilises IHE format was proposed for semantic interoperability of data in the Namibian environment, and specifically the HL7 standards for messaging. In addition to the framework, a prototype that demonstrates how disease surveillance data can be integrated into the Namibian environment based on the developed profiles was developed for proof of concept.

The Centre for Disease Control (CDC) in Namibia assists the MoHSS to develop and implement a comprehensive package of disease prevention, care and treatment programs for communicable and non-communicable diseases, particularly HIV, cancer, stroke, tuberculosis, heart disease, TB, diabetes, malaria, diarrhoeal diseases, and respiratory infections (Global Health-Namibia, 2017). It supports the MoHSS to conduct disease surveillance activities, monitor and evaluate such activities, research and maintain HIS (CDC, 2013). Currently, data is communicated to the CDC through the directorate of special programmes that deal with HIV/AIDS, TB, malaria, and related diseases and through primary healthcare directorates in the different regions of the MoHSS (Tariqul Khan & Edwards, 2012). However, as a result of poor and inefficient communication of disease surveillance information, there is little or no data coming in from the regions for real-time decision-making in cases where an outbreak of disease requires prompt action. The methods used currently to communicate data from the regions to the CDC are emails or phone calls. These methods are not appropriate in cases of emergency in disease control.

The study proposed crowdsourcing as one of the methods of collecting data on disease surveillance from the communities which is then integrated into the HIS. Crowdsourcing is the practice of obtaining information or input into a task or project by enlisting the services of a large number of people, typically via the internet (Kleemann, Voß, & Rieder, 2008). It is noted that in Namibia, cell phone coverage stands at over 100% and hence, the concept of mobile crowdsourcing (MCS) would work perfectly well (Angula, 2018). MCS is a term that describes crowdsourcing activities that are processed on mobile devices.

The study also proposed community health workers (CHW) as one of the methods to communicating disease surveillance information to the relevant authorities as a real –time method of communicating such information. For crowdsourced information from the communities' mobile phones to be integrated with other HISs in the Namibian health network, health level seven (HL7) standards are adopted.

The study also proposed hospital-to-hospital exchanges as one of the methods of collection of disease surveillance data to allow the main DHIS-2 and such silo systems that are in the Namibian public hospitals to work as an integrated platform that can be used to share and exchange important disease-surveillance information through adopting health standards. In all these three cases, the data collected has to be integrated with the network of heterogeneous HIS; hence the need for semantic interoperability of all these HIS.

The problem in Namibia's health sector is that there is a plethora of silo HIS that generate much data which cannot be integrated for efficient decision-making since these silo systems do not communicate with each other (Haoses-Gorases, 2015). Almost all public hospitals in Namibia host a HIS of one form or the other, but sharing the data they produce with other hospitals and with the MoHSS is curtailed as a result of a lack of interoperability.

1.2 Problem statement

The Centre for Disease Control (CDC) in Namibia is experiencing challenges in timeously accessing disease surveillance information from the regions through its head office in Windhoek, irrespective of the fact that there are HIS in all the regions of Namibia (CDC, 2013). CDC regional offices also find it difficult to access communicable and non-communicable disease information on time from the CDC regional sub-offices, especially considering that the regional sub-offices host HISs as well. Currently, it takes on average about a month for CDC regional offices to access disease surveillance information from the regions after an incidence has been reported (Angula& Dlodlo, 2018). This might be due to the fact that the current method of communicating disease surveillance information is not appropriate as it does not support real-time access to information from regional offices across the country for prompt decision-making.

The present study developed a prototype as a solution to sematic interoperability that aggregate data from different sources or HIS. The study developed a system that will aid in health decision-making because the system has the capability of aggregating data from remote systems. It will organize data coming from different HIS or from different health facilities in Namibian public institutions. This would address the current problem of a traditional method of accessing, exchanging and communicating disease surveillance data from one public health institution to other public health institutions. The system has the ability to organize distributed data source from heterogeneous health system without changing the content of the data as long as data can support JSON format and as result the representations of data will be displayed in the format of pie charts and graphs. The charts and bar graphs show the health institutions source, geographical location, gender, type of disease. In addition the system will offer public health institutions in Namibia the opportunity to access disease surveillance data in real-time for decision-making. The health professionals will be enabled to work jointly when making health decisions. The system will allow disease self-management which means health professionals will access all the disease information from different sources.

The community health workers in the Namibian health domain are experiencing challenges of communicating disease surveillance information on time to the relevant health facilities across the country (MoHSS, 2014). The community health workers in the Namibian health environment do not have a framework that guides them as to how to communicate disease surveillance information to the health decision-makers real-time (Angula, 2018). The CDC agency as the custodian of disease surveillance information coordinates and facilitates the collection and communication of non-communicable and communicable disease information. They face the challenge of exchanging disease surveillance information to other regions in Namibia. As a result, community health workers are usually deployed in the 14 regions in Namibia to gather disease surveillance information. The process of access to information is long, for instance a month or more (CDC, 2013).

The current methods used to collect data is that community health workers are normally sent to the field to inspect the situation of non-communicable and communicable diseases that occur in the region and as a result community health workers compile reports on specific issues of disease occurrence. This is time consuming as the information has to be sent to the head office in Windhoek where strategic decisions are taken and implemented (CDC global health strategy, 2010-2015). The community health workers in the Namibian health domain struggle a lot when they are in the field as they find themselves in deep remote areas where the telecommunications networks are limited. As a result, the research is motivated to develop a semantic interoperability framework as a solution or improvement to this current problem experienced by the community health workers in Namibia when collecting disease surveillance data in the regions. WHO (2008) states that surveillance should be conducted for diseases and conditions considered to be of public health importance. The list of diseases and syndromes in the national HIS is useful for planning and routine management but too extensive for effective and useful surveillance in view of the limited human and financial resources. Therefore, depending on the objectives of the system, priority diseases for surveillance should be identified and reviewed regularly to ensure they remain relevant and important. There are no HL7 standards for community health workers to be supported in a standardised manner. In general, there are research efforts that standardise communications among healthcare workers.

While interoperability represents the accurate exchange of information and the use of information for effective decision-making, for information (data) exchange to occur it must be interpretable between multiple information systems (Berryman, Yost, Dunn, & Edwards, 2013). The issue as it stands is that, the silo systems that are hosted by the MoHSS are stand-alone and they do not communicate and/or they are not inter-linked with each other, which makes the process flow of health-related information between hospitals difficult thereby reducing service delivery and performance.

The problem in Namibia's health sector is that there is a plethora of silo HIS that generate numerous disease surveillance data which cannot be integrated for efficient decision-making as these silo systems do not communicate with each other, hence there is no real-time exchange of disease-surveillance information. Almost all public hospitals in Namibia host an HIS of one form or the other, but sharing the data they produce with other hospitals and with the MoHSS is curtailed as a result of a lack of interoperability (Angula, 2018). However, the current challenge in the Namibian health domain is that the HISs are unable to speak the same language and recognise the formats, structure and core codes in their communication. The need arises therefore for an approach to enable the semantic interoperability of Namibia's heterogeneous silo HIS so that they can share and exchange disease surveillance data for informed decision-making.

Although international standards such as IHE and HL7 for health information integration exist in the world today, Namibia is yet to adopt these standards, hence the motivation for this research. These standards would enable Namibian HIS to communicate and share data, including disease surveillance data. There is a challenge of accessing disease surveillance data from one Namibian public hospital to the other hospital due to the lack of interoperability of HIS. The problem of technical variations in the different technology architectures, service models and capabilities make it difficult for one to create a single standard format for the sharing of data (Challenges of establishing EHR interoperability, 2018). This study sought to develop and design a comprehensive international health standards-based framework for enabling semantic interoperability of disease surveillance data for the Namibian health setting. The study developed a framework for a health information data interface system that can enable the main DHIS-2 to connect to various silo systems in the Namibian public hospitals for health-related information sharing at data level.

1.3 Research aim and objectives

This section is on the research aim and objectives.

1.3.1 Aim

The aim of this research was to design and develop a comprehensive standards-based framework for data semantic interoperability of DHIS-2 and other health information silo systems in Namibia so that they can exchange disease surveillance health data and information through adopting health standards of IHE and HL7.

1.3.2 Objectives

The objectives of this research were to:

i. Assess how disease surveillance data are currently exchanged/shared between the existing DHIS-2 and silo systems in Namibia;

ii. Examine how existing DHIS-2 and silo systems in Namibia can be interfaced;

iii. Develop a data interlink protocol/profile that would govern heterogeneous health information systems in Namibian public hospitals; and

iv. Design and develop a comprehensive standards-based framework to enable semantic interoperability of data in heterogeneous health information systems in Namibian hospitals through adopting health standards.

1.4 Research questions

The following section is on the main research question and sub-questions.

1.4.1 The main research question

The main research question is: “How can the comprehensive standard-based framework for disease surveillance data semantic interoperability of DHIS-2 and the other Namibian health information silo systems for them to exchange disease surveillance data and information be achieved using health standards”?

1.4.2 The sub-questions

The sub-questions of this research were:

- **i.** How is disease surveillance data currently shared between existing DHIS and silo systems in Namibia?
- **ii.** How can information relating to disease surveillance data be interfaced between existing DHIS-2 and silo systems in Namibia by adopting health standards?
- **iii.** How can a data interlink/ profile protocol that can govern heterogeneous health information systems in Namibian public hospitals be developed whilst adopting health standards?
- **iv.** How can a comprehensive standard-based framework to enable semantic interoperability of disease surveillance data in heterogeneous health information systems in Namibian hospitals be designed and developed through adopting health standards?

1.5 Gaps identified in the research

This study identified a gap in the Namibian public hospitals which lies in the lack of semantic interoperability of data which hinders the Namibian public hospitals from sharing disease surveillance health information timeously and efficiently with the MoHSS. This is as a result of the fact that Namibia has failed to utilise international health information standards which enable the interoperability of data. The absence of a framework to enable the interoperability of disease surveillance data was the gap identified by this research.

1.6 Significance of the research

This research study aimed at designing and developing a framework to enable the semantic interoperability of data in heterogeneous health information systems in Namibian hospitals. No such research has been conducted in the Namibian health sector.

- DHIS-2 and silo systems would be provided with an interaction channel through which disease surveillance information would be shared between public hospitals in Namibia.

- The outputs from the research would address the challenge facing the government public hospitals with regards to access to disease surveillance information.
- The study contributed to the professional development of the researcher who would want to gain a broad understanding of semantic interoperability of data in heterogeneous health information systems in Namibian health institutions.

1.7 Validity and Reliability

The study ensured validity and reliability of the information collected from respondents on interoperability of Namibia HISs in terms of accuracy. Confidentiality was maintained between the study and respondents. The study carried a pilot study to validate the research questions. The study used expert reviews to validate the three prototypes developed as proof of concept.

1.8 Limitations of the study

Although there are hundreds of health institutions in the country, the study covered only eight public health institutions in selected regions as cases in Namibia. The sparsely populated regions of the country were a possible obstacle to this research study. This was so as the researcher was also not able to visit all the public health institutions country wide for data gathering and capturing purposes due to financial constraints.

1.9 Assumptions

For the study purpose, the following assumptions were put forward:

I. The Namibian public health institutions are interested in the integration of DHIS-2 and silo systems

II. The MoHSS would support the research

III. Publishers of books for public health institutions would be ready to review content to suit the outcomes of the research

IV. Public health institutions in developing nations are different from rural public health institutions in developed countries

V. The expectation is that all participants would provide honest and reliable responses to the survey items.

1.10 Ethical considerations

As stated in the research objectives and indicated in the research methods section, the research was carried out in eight regions with selected public hospitals in Namibia. Research ethics clearance was sought from the Durban University of Technology, under which this study is conducted, and it was strictly adhered to throughout the course of this research. Research clearance was also sought from the MoHSS for access to the hospitals for data collection. The study abided to the ethics of public hospitals and human research.

1.11 Conclusion

The problem in Namibia's health sector is that there is a plethora of silo HIS that generate much data which cannot be integrated for efficient decision-making due to the fact that these silo systems do not communicate with one another. Almost all public hospitals in Namibia host an HIS of one form or the other but sharing the data they produce with other hospitals and with the MoHSS is curtailed as a result of a lack of interoperability. This thesis reports on an approach to enable the semantic interoperability of Namibia's heterogeneous silo HIS so that they can share and exchange disease surveillance data for informed decision-making. This semantic interoperability is achieved through the adoption of international standards such as IHE and HL7 for health information integration. Namibia is yet to adopt these standards, hence the motivation for this research. For proof of concept, this research developed a prototype to demonstrate how disease surveillance data can be integrated through an Interlink protocol.

The next chapter covers background literature.

CHAPTER 2: BACKGROUND LITERATURE

2.1 Introduction

This chapter discusses a comprehensive examination of the existing research on this study topic. The purpose of this background chapter was to establish what is already known about this topic and what methods have been used in other researchers' topics similar to this study. In addition, by doing so, this prevented the study from reproducing what is already known. The background literature helped to expose the gaps in the literature as well as position the research. The purpose of this chapter was also to provide a background on the scientific and general overview of keywords related to the research study and these were: interoperability, types of interoperability, semantic interoperability, data interoperability, challenges of interoperability, Information and communication technologies, ICTs for health in Africa and HL7.

2.2 Interoperability

There are a number of definitions of interoperability given by different authors. According to Iroju, et.al (2013), interoperability is the ability of different information and communications technology systems and software applications to communicate, to exchange data accurately, effectively, and consistently, and to use the information that has been exchanged (Iroju, Soriyan, Gambo, & Olaleke, 2013). Interoperability is also defined as "the ability of information systems to operate in conjunction with each other, encompassing communication protocols, hardware, software applications and data compatibility layers" (Interoperability Clearinghouse Glossary of Terms). Interoperability is also defined by NISO (2003) as "the ability of multiple systems with different hardware and software platforms, data structures, and interfaces to exchange data with minimal loss of content and functionality" (NISO, 2003, pp. 4-33). According to Carlile (2004), interoperability refers to the ability of a system to use and share information or functionality of another system by adhering to common standards (Carlile, 2004). Without agreed standards shared by at least two systems, processes or other actors which are aiming at interoperability, interoperability is not possible. Moreover, interoperability is the ability of two or more systems or components to interchange information and use predictably the information that has been exchanged" (Fetter, 2009). Interoperability also means the ability to communicate and exchange data accurately, effectively, securely and consistently with different ISs, software applications and networks in various settings and exchange data such that clinical or operational purposes and meaning of the data are preserved and unaltered (Fetter, 2009). Interoperability can occur only when some degree of compatibility exists among all elements that must cooperate for some purpose. Interoperability is based on the existence of (and cannot occur lacking) a single, common conceptual view (Carney & Oberndorf, 2004). In broad terms, interoperability is the ability of different information and communications technology systems and software applications to communicate, exchange data accurately, effectively and consistently and to use information that has been exchanged (Iroju, 2013).

Interoperability is a property referring to the ability of diverse systems and organizations to work together (inter-operate). Interoperability works in different areas like telecommunications, software and hardware, medical industry, e-government, public safety, railways, business and libraries. Interoperability is the ability of two or more systems or components to exchange information and to use the information that has been exchanged according to IEEE. According to ISO/IEC 2382-01, interoperability is defined as: "The capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units" (pp.34-43). According to Gridwise (2008) interoperability incorporates the following characteristics:

- Exchange of meaningful, actionable information between two or more systems across organisational boundaries.
- A shared understanding of the exchanged information.
- An agreed expectation for the response to the information exchange.
- A requisite quality of service: reliability, fidelity, and security.

In the Namibian context interoperability of HIS is a main concern. The issue here would be how to enable the semantic interoperability of crowd-sourced data with the plethora of heterogeneous HIS in the Namibian health sector. The second problem is that in Namibia’s health sector there is a plethora of silo HIS that generate a lot of data which cannot be integrated for efficient decision-making due to the fact that these silo systems do not communicate with each other. Almost all public health institutions in Namibia host an HIS of one form or the other, but sharing the data they produce with other health institutions and with the MoHSS is curtailed because of a lack of interoperability.

2.2.1 Data Interoperability

This research is on semantic interoperability of disease surveillance data. Therefore, this section is on data interoperability. Data interoperability is the ability to correctly interpret data across systems or organizational boundaries (Iroju et al., 2013). Data interoperability is defined as the ability to correctly interpret data across different systems or organizational boundaries (NITDA,2016). It is about facilitating a common understanding of the data meaning and usage between systems and across agencies - providing clarity in plain English or familiar business language. Implementing data interoperability requires achieving both data integration and data exchange as well as enabling effective use of the data that becomes available. Each of these three tasks involves some type of standards and guidelines in the way data is captured and consumed between disparate systems. Data semantics irregularities are most commonly evidenced through differences in: data names; data types; data lengths; and data structures. In the Namibian health sector interoperability is the main concern because data generated by different health information systems are of different format, unstructured data which make the complexity of heterogeneous HIS to be interoperable.

Data interoperability denotes the ability of different software from heterogeneous systems to understand the syntactical and semantic meaning of data from different data models through the use of common data models, mappings and structures (Van Staden & Mbale, 2012). Data interoperability is a necessity for achieving sharing of data across communities and domains. This problem is exacerbated when it comes to global research data infrastructures that serve a wide range of communities of practice, potentially involved in very diverse application scenarios, each requiring information to be shared. One of the defining characteristics of HIS is that they are very data-intensive. As a result of this, a major challenge with data intensive HIS is the lack of product interoperability. The adoption of health standards such as the HL7 messaging standard (Health Level Seven, 2018), for defining a common message structuring scheme for message exchange between medical information systems, and the IHE (Sinha, 2012), is an important step in enabling the interoperability of HISs. The ability of HIS to speak the same language and recognise the formats, structure, and care codes in their communications is a critical component in determining the success of interoperability initiatives and the ability to improve care levels.

Barbarito et al. (2012), state that ICTs have now entered the everyday workflow in a variety of healthcare providers with a certain degree of independence. This independence may be the cause of difficulty in interoperability between information systems and it can be overcome through the implementation and adoption of standards. Furthermore, William (2004) articulates that in the three decades since the term “medical informatics” was first used, individuals working at the intersection of ICT and medicine have developed and evaluated computer applications aiming to improve health and healthcare. The road to successful use of ICT in medicine has not been easy, with examples of failures in both computer systems and networks. However, a variety of applications from the field of medical informatics have matured in recent years.

Today, most patient information is stored in disparate systems across the healthcare community, that, is, in physicians’ offices, imaging clinics, and other hospitals, and many of these systems do not interoperate. A practitioner in a private practice may have difficulty obtaining complete information about a patient currently being hospitalised, or a practitioner may repeat tests and procedures because he or she does not have prior information about the patient.

The WHO (2012) report states that ICTs have great potential to improve health in both developed and developing countries by enhancing access to health information and making health services more efficient; they can also contribute to improving the quality of services and reducing their cost. Patient ISs, for example, have the ability to track individual health problems and treatment over time, giving insight into optimal diagnosis and treatment of the individual as well as improving the delivery of services. This is particularly useful for chronic diseases, such as diabetes and cardiovascular diseases, and for maternal and child health services where a record of health and treatment over a period of time is required. Analysis of data in patient ISs can lead to new insight and understanding of health and disease, both chronic and acute. The study argued that interoperability assessment is necessary to identify barriers to interoperability and prioritise areas of quality improvement with regard to interoperability. A predictive approach to interoperability assessment is desirable since it is more cost effective and can support proactive decision making (Murie, 2015).

Sachdeva and Bhalla (2010) show in their previous work that healthcare information is complex, distributed and non-structured in nature. Integration of information is important to retrieve patient history, for knowledge sharing and to formulate queries. Large-scale adoption of electronic healthcare applications requires semantic interoperability. Interoperability of electronic health records (EHRs) is important because patients have become mobile, treatment and healthcare providers have increased, and also have become more specialised.

In the context of scientific investigations, data has acquired an ever-growing leading role and their large scale, cross community and cross-domain sharing have concurred to identify new investigation paradigms (Hey, Tansley, & Tolle, 2009). Unfortunately, data interoperability – a mandatory prerequisite for achieving the above scenarios – is still a difficult open research challenge. Both the “data” and “interoperability” concepts are difficult to be fully perceived and actually lead to different perceptions in diverse communities. This problem is further amplified when considered in the context of (global) research data infrastructures that are expected to serve a plethora of communities of practice (Lave & Wenger, 1991) potentially involved in very diverse application scenarios, each characterised by a specific sharing problem.

Interoperability connections can be used to aggregate files, perform translations on the fly, define a coordinate system, and store format-specific parameters such as database connections and passwords. All interoperability connections are saved in the interoperability connections folder (ESRI, 2010).

ICTs play significant roles in the improvement of patient care and the reduction of healthcare costs by facilitating the seamless exchange of vital information among healthcare providers. Thus, clinicians can have easy access to patient’s information in a timely manner, medical errors are reduced, and health-related records are easily integrated. However, as beneficial as data interoperability is to healthcare, at present, it is largely an unreachable goal (Iroju et al., 2013).

Greenwell & Hill (2018) states that developing a global health indicator registry with standards for data, indicators, metadata, and references to analytic methods that build upon work done in health and disease program, promotes the implementation of the standards.

The study conducted by Ingenieurim, Coleman (2016) articulate that over the last two decades, the number of healthcare services at the edge of the traditional medical care and computer technologies has increased dramatically, making eHealth infrastructure-related services ubiquitous. Services such as telemedicine, telehealth,EHR systems are common terms and practices in the actual medical-care sector. A main characteristic of HIS is that they are very data-intensive systems. In this respect, a major problem is the lack of product interoperability. The publication of standards such as the HL7 messaging standard for defining a common message structuring scheme for message exchange between medical information systems, or the adoption of the IHE profiles for specifying use cases that implementers should follow, is an important step in enabling interoperable HISs. eHealth is the healthcare and delivery process that are supported by electronic and communication technology. Some of the eHealth applications used today are patient ISs, ePrescription, lab systems, electronic health records etc. One or more times every eHealth tool (here tool represents a software application) would communicate with other eHealth tools for information exchange. The communication of these tools gives birth to interoperability that should actually make the information exchange easier. eHealth interoperability is the ability of one or more computers and software applications communicate with each other for health information exchange and make use of the information. More communication among the tools makes the communication complex and interoperability challenging. Oracle Technical White Paper (2010) states that the American Recovery and Reinvestment Act of 2009 (ARRA) has earmarked approximately $19 billion to help physicians and hospitals achieve “meaningful use” of health information technology (HIT).

At its core, ARRA’s landmark meaningful use initiative is meant to help providers collect and store different combinations of electronic patient data—allergies, medication history, lab results, clinic visits—in an electronic health record (EHR) and then securely share this data with other health entities and governmental agencies. These capabilities will most certainly raise healthcare organisations to a new level of efficiency. But even more importantly, they will enable safer, more accountable, and more personalized care. One of the chief hurdles to providers’ achieving meaningful use and secure health information exchange (HIE) is the actual interoperability of their HIT systems with other entities’ systems. The ability for providers’ systems to speak the same language and recognise the formats, structure, and care codes in their communications is critical in determining the success of the meaningful use initiative and the ability to improve care levels. Further, an organisation’s level of interoperability will become a new competitive benchmark.

Carrol, Cnossen, Schnell, and Simons (2007) note that the healthcare industry must improve its delivery methods and reduce costs to address current and anticipated needs. Various technologies could help by extending treatment and care beyond traditional clinical settings into personal and home settings. However, creating such a personal telehealth ecosystem will require interoperability. Device connectivity to enterprise services is currently very proprietary. In an effort to develop interoperability guidelines for the emerging personal telehealth ecosystem, we formed the Continua Health Alliance (www.continuaalliance.org), an international alliance of more than 133 companies.

Sachdeva and Bhalla (2010) report that healthcare information is complex, distributed and non-structured in nature. Integration of information is important to retrieve patient history, for knowledge sharing and to formulate queries. Large scale adoption of electronic healthcare applications requires semantic interoperability. Interoperability of electronic health records (EHRs) is important since patients have become mobile, treatment and health care providers, have increased and also, have become more specialised.

Reisman, (2017) state that creating interoperability among healthcare systems to seamlessly and easily exchange information in near real-time is critical to making meaningful improvements in healthcare delivery. Interoperability is complex and cannot be solved by focusing only on individual standards and quasi solutions.

Data interoperability is the ability to correctly interpret data across systems or organisational boundaries. However, with the rising cost of healthcare, incessant inefficiencies and healthcare quality failures experienced by healthcare providers and patients, there is a need to understand the critical role that interoperability plays in data sharing and re-use among disparate healthcare applications and devices, reduction of healthcare costs and improvement in the quality of care. Interoperability connections can be used to aggregate data. Data integration bring multiple formats together.

Experience suggests that, left to their own devices, the designers of individual systems will often make locally optimal decisions about data definitions and format. Data formats resulting from such local decisions may not be compatible when operational requirements dictate that a network of systems be called upon to interoperate. Thus, architectural design must provide guidance to developers to minimise the applications-layer incompatibilities that inevitably arise when systems with different purposes must communicate with each. Data interoperability includes single data definition for all systems. This approach can be problematic when applied on a large scale to a complex, evolving system or system of systems (Kasunic, 2001). Furthermore, interoperability can be a daunting concept for any industry. In healthcare, it is even more complex, given the number of stakeholders: patients, doctors, nursing staff, hospitals, nursing homes, payers, and vendors. The list goes on and on. To top it off, healthcare stakeholders are used to living in their own silos, with information tailored only for them. For years, hospitals and other health provider organisations have stitched together systems with interfaces. For nearly ten years, the healthcare industry has been discussing the need and vision for interoperability of health information. But a lot of healthcare organizations - and even IT solutions for healthcare — have been predicated on supporting information silos. So, the health information industry has been in a mindset that drove the need for integration via interfaces instead of interoperability. But the old way of “stitching it together” does not work anymore.

Data interoperability addresses the ability of systems and services that create, exchange and consume data to have clear, shared expectations for the contents, context and meaning of that data (Berryman, Yost, Dunn, & Edwards, 2013). Data interoperability is essential in semantic interoperability of heterogeneous health information systems due to the fact that one or more silo information systems can exchange data with another. Therefore, the study would create an integrated platform to enable semantic interoperability of data in heterogeneous health information systems in public hospitals in Namibia. Data interoperability across heterogeneous systems can be hampered by differences in terminology, particularly when multiple scientific communities are involved. Data Interoperability in its most concise explanation is the ability of systems to exchange information and then use the information exchanged effectively (Berryman, Yost, Dunn, & Edwards, 2013). Problems of systems interoperability are prevalent in the healthcare industry and recent regulatory changes have caused drastic business strategy shifts within the sector. In prior healthcare system implementations, vendor solutions had minimal incentive to standardize any aspects of their Health Information Exchange (HIE) and the information systems they were bound to. Overall, HIE aims to keep records, diagnosis, and treatment integrated between healthcare organizations to ensure patient data integrity along with preventing data loss (Dimitropoulos & Rizk, 2009). Marketplace dominance of specific vendors has caused defacto standardization, bringing a series of unique problems to progress in regard to interoperability, security and the business operations it supports. The need standardized models in systems design for industry technology is being demanded (Association for the Advancement of Medical Instrumentation, 2012). A key success factor brought to light is the cooperation between the practitioners, the industry and the standards bodies (Aylward, Woodhall & Lent, 2007). This preference shift is a result of regulatory compliance and is defining the need for data interoperability with best practice security measures implemented along its side. Data interoperability continues to be a significant challenge for researchers to address several issues (Pagano, Candela, & Castelli, 2013). The 'data' and 'interoperability' concepts are difficult to be fully perceived and actually lead to different perceptions in diverse communities. This problem is further amplified when considered in the context of research data infrastructures that are expected to serve a number of communities of practice potentially involved in diverse application scenarios, each characterized by a specific sharing problem. The term 'interoperability' does not have a clear definition shared by the overall community despite being used to describe a core class of problems in many systems and application scenarios. Data integration, and data exchange are confused, as they share some commonalities in terms of issues and goals. Implementing data interoperability requires realizing data integration and data exchange along with an enabling effective use of the data that become available (Pagano, Candela, & Castelli, 2013).

2.3 Types of interoperability

Interoperability among the HIS is observed mainly at three levels and these are: semantic (Schuurman, 2005), social, and technical (van der Veer, 2008). Semantic interoperability is about how two or more tools share information and make use of that information. Technical interoperability is about the technologies and networks used to communicate among those applications. Social interoperability is concerned with the environment and the human processes involved in the information exchange. The healthcare information is complex, distributed and non-structured in nature (Batra, 2015). Furthermore, Batra (2015) states that integration of information is important to retrieve patient history, for knowledge sharing and to formulate queries. Large scale adoption of electronic healthcare applications requires semantic interoperability. Interoperability of electronic health records (EHRs) is important because patients have become mobile, treatment and health care providers have increased and also, have become more specialised.

According to ETSI (2008), technical interoperability encompasses hardware/software components, systems and platforms that enable communication between different machines to take place. This kind of interoperability is often centered on common communications protocols and the infrastructure needed for those communication protocols to operate (ETSI, 2008). According to ETSI (2008), syntactic interoperability is about data formats. This means that the messages transferred by communications protocols require a well-defined syntax and encoding. However, many protocols carry data or content that is represented using transfer syntaxes such as HTML, XML or ASN.12. According to Guijarro (2007), semantic interoperability ensures that the meaning of information that is exchanged can be understood by any other application that was not initially developed for this purpose. Semantic interoperability enables one system, for example, to combine the information it receives with other information resources and to process it into a meaningful form. Guijarro (2007) further states that creating interoperability among healthcare systems to seamlessly and easily exchange information in near real-time is critical to making meaningful improvements in healthcare delivery. Interoperability is complex and cannot be solved by focusing only on individual standards and quasi solutions but through a holistic approach. Social interoperability: To discuss about the social interoperability, Landsbergen and Wolken (2001), mention its importance from different domains of economic, political, technical, and organizational as involved in information sharing. They define social interoperability as the support mechanism to understand the relationship among these domains.

Tolk, Saikou, & Charles (2007) define 7 levels of interoperability:

- Level 0 or no interoperability
- Level 0 or no interoperability: This is usually characterised by stand-alone systems which have no interoperability.
- Level 1 or technical interoperability: This level of interoperability involves the use of a communication protocol for the exchange of data between systems. According to the study of the HL7 group, the focus of technical interoperability is about the conveyance of data, not its meaning (EIF, 2004). That means, technical interoperability is about the tools and techniques to transfer data rather than concerned about how the data would be realized. The HL7 group also observed that this type of interoperability is mentioned mostly alone and sometimes with other types of interoperability.

2.3.1 Syntactic interoperability

- Level 2 or syntactic interoperability: This is the ability of two or more systems to exchange data and services using common interoperability protocols such as High Level Architecture (HLA). Syntactic interoperability is the ability of one computer system to import the utterance created by another computer system and validate the utterance against a particular grammar and/or set of construction rules such as where a computer imports an XML document and validates it against a corresponding XML schema(Dolin & Alschuler, 2011). Syntactic interoperability may be ensured if two systems follow the same technical specifications for processing an identifier string, where the scope of the likely identifiers to be encountered is reasonably predictable. In certain cases, rules may exist for directly incorporating an identifier from one scheme in the syntax of another scheme (Ashrafi, Kuilboer, & Stull, 2018). If a system is capable of communicating and exchanging data, it is syntactic interoperable. For communicating data, specified data formats, communication protocols, interfaces of descriptions and the like are fundamental. In general XML or SQL standards provide syntactic interoperability.

2.3.2 Semantic interoperability

Semantic interoperability and integration is concerned with the use of explicit semantic descriptions to facilitate information and systems integration (Kalfoglou, Schorlemmer, Uschold, Sheth, & Staab, 2004). Due to the widespread importance of integration, many disparate communities have tackled this problem. Semantic Interoperability plays a pivotal role in healthcare organizations enabling ubiquitous forms of knowledge representation. By integrating heterogeneous information, it strives to answer complex queries and pursue information sharing in healthcare. Its absence within and across organizational boundaries, however, impedes the ability to exchange information in a complex network of computerized systems developed by widely different manufacturers (Ashrafi, Kuilboer, & Stull, 2018). Ashrafi, Kuilboer and Stull (2018) state that there is a need to achieve semantic interoperability and explore the implementation challenges and roadblocks that exceed the technical difficulties and evolves around cultural, social, policy and economic barriers to data sharing. Semantic Interoperability is the key to data exchange and service creation across large vertical applications as seen as next step of evolution of the IoT (Jacoby, Antonid, Kreiner, Łapacz, & Pielorz, 2017). In order to enable building new innovative applications which make use of data from multiple existing vertical IoT silos these systems must not only be able to exchange information but also have a common understanding of the meaning of this data. This means, even if today's IoT systems are willing to expose their data and resources to others their semantically incompatible information models become an issue to dynamically and automatically inter-operate as they have different descriptions or even understandings of resources and operational procedures. To enable dynamic and automated interoperability new features like semantic annotation, well-defined semantic mapping, unified resource discovery and federated authentication and authorization are required which cannot solely

- Level 3 or semantic interoperability: This refers to the ability of two or more systems to automatically interpret the information exchanged meaningfully and accurately in order to produce useful results as defined by end-users. Semantic interoperability refers to the ability of two or more systems to automatically interpret the information exchanged meaningfully and accurately in order to produce useful results as defined by the end users of the systems (Iroju et al., 2013). Semantic interoperability is also used in a more general sense to refer to the ability of two or more systems to exchange information with an unambiguous and shared meaning (Iroju et al., 2013). Semantic interoperability implies that the precise meaning of the exchanged information is understood by the communicating systems. Hence, the systems are able to recognize and process semantically equivalent information homogeneously, even if their instances are heterogeneously represented, that is, if they are differently structured, and/or using different terminology or different natural language(Iroju et al., 2013). Semantic interoperability can thus be said to be distinct from the other levels of interoperability because it ensures that the receiving system understands the meaning of the exchange information, even when the algorithms used by the receiving system are unknown to the sending system. Semantic interoperability and integration is concerned with the use of explicit semantic descriptions to facilitate information and systems integration (Kalfoglou, 2004). In the hospital set up, interoperability is essential simply because it allows systems to exchange meaningful, actionable information between two or more systems across organisational boundaries, a shared understanding of the exchanged information, an agreed expectation for the response to the information exchange and also a requisite quality of service: reliability, fidelity, and security (AIOTI, 2015). In addition, two information systems are semantically interoperable if and only if each can carry out the tasks for which it was designed for using data and information taken from the other as seamlessly as using its own data and information.

- Level 4 or pragmatic interoperability: This is achieved when the interoperating systems are aware of the methods and procedures that each other are employing so that the use of data and context of its application is understood by the operating systems.

- Level 5 or dynamic interoperability: when two or more systems are able to comprehend the state changes that occur in the assumptions and constraints that they are making over time, and they are able to take advantage of those changes.

- Level 6 or conceptual interoperability is reached if the assumptions and constraints of the meaning full abstractions are reality aligned.

- The present study is limited to semantic interoperability that would aggregate surveillance data in the Namibian public health sector. This is so because silo health information systems in Namibia works in isolation and as such no sharing of surveillance data from different silo systems in Namibian health domain.

2.4 Challenges of data interoperability

As a highly challenging and multifaceted task, data interoperability subsumes a lot of challenges and research topics including: lack of a common problem definition, coping with variety, enabling data reuse, agreeing on common standards, and developing comprehensive approaches. The lack of a common problem definition might seem a trivial aspect (Pagano, Candela, & Castelli, 2013). On the contrary, it is a fundamental issue that prevents the overall community from working in synergy towards the identification of proper strategies and solutions. As already mentioned, there is neither a definition of interoperability nor one of data and data interoperability that is shared across different communities and domains. However, different communities have faced and will face data management and data interoperability problems in the context of their application scenarios. Very often these communities have no specific expertise in data interoperability and will follow a pragmatic approach oriented to resolving the specific issue they are confronted with. Very often they develop from scratch an ad-hoc solution while having no, or very limited, knowledge of approaches and solutions developed by other communities in similar cases. All this is a result of the lack of a common framework that can be used to describe the interoperability problem in all its facets in a structured and unified manner – well beyond the technical interoperability that although fundamental is only a part of the problem. Once available, such a framework could be used to describe interoperability approaches and solutions in a systematic way in order to ensure that they are discovered thus avoiding a scenario where these valuable resources remain confined to the domain in which they have been developed. Coping with variety is a very broad yet characterizing aspect of interoperability. Variety is a characteristic spanning the entire spectrum of data features when they come from different and independent data sources. In a (global) research data infrastructure, data to be managed might be heterogeneous with respect to their type, accuracy, size, semantic, etc. Some of these variety aspects are objective or application-agnostic, i.e., they exist independently of the characteristics of the interoperability scenario, while others are subjective or application-specific, i.e., their existence depends on the needs of the specific interoperability scenario.

The boundary between objective and subjective aspects is a parameter difficult to estimate; in many cases it is application-specific. To make it possible for every “user” of data to decide which are the data variety aspects owned by given data that might be tolerated and which are those to be removed, a common approach is to enrich the data with others’ data, capturing data variety, e.g., data provenance (Moreau, 2010) as well as data annotations and metadata aiming at characterising data quality aspects (Batini & Scannapieco, 2006). Unfortunately, there is neither a standard universally accepted for these data nor a widely accepted approach for dealing with diverse materialisations of such “additional” data. This calls for approaches for data provenance / data quality interoperability. Enabling data reuse is an aspect that characterises data interoperability with respect to similar problems, e.g., data exchange. In some contexts, data have value if and only if they can be re-used. In order to make it possible for an entity to actually re-use data that have been collected or produced by a different entity, it is fundamental that a rich set of contextual information about such data be made available. Therefore, open research problems are (a) the characteristics this set of contextual information should capture, (b) the format this information should be represented in, and (c) the manner this information should be communicated.

2.5 Information and communication technologies

Information and Communication Technology (ICTs) is an extended term for information technology (IT) which stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary software, its storage and the audio-visual systems, which enable all users to access, store, transmit, and manipulate information (AIBARA ,2017). The term ICT is also used to refer to the combining of audio-visual and telephone networks with computer networks through a single cabling or link system (AIBARA, 2017). There are large economic incentives (huge cost savings due to elimination of the telephone network) to merge the telephone network with the computer network system using a single unified system of cabling, signal distribution and management. However, ICT has no universal definition, as "the concepts, methods and applications involved in ICT are constantly evolving on an almost daily basis. “The broadness of ICT covers any product that will store, retrieve, manipulate, transmit or receive information electronically in a digital form e.g. personal computers, digital television, email and even the modern day robots.

ICTs are diverse set of technical tools and resources to create, disseminate, store, brings value addition and manages information(Amit Arrawatia & Meel, 2012). The ICT sector consists of segments as diverse as telecommunications, television and radio broadcasting, computer hardware, software and services and electronic media, for example, the internet and electronic mail. Since the 1990s, advances in ICTs in healthcare have created new ways of managing patients’ information through the digitisation of health-related information (Iroju, 2013). The use of ICTs in healthcare has the potential of reducing medical errors, improving collaboration between healthcare providers, reducing the cost of healthcare and dramatically improving the delivery and quality of healthcare. The enhancement of ICTs in healthcare has also led to the generation of huge amounts of information relating to the diagnosis, testing, monitoring, treatment and health management of patients, billing for healthcare services and asset-management of healthcare resources.

Brooks (2010) points out that data interoperability is a key ingredient for modern health ICT. Interoperability of HIS is essential for the communication of critical data, as well as for leveraging the vast amounts of data gathered to conduct research, analyse trends, improve safety, and reduce healthcare costs. One of the critical components for enabling interoperability is the availability of data standards. Over the last few years, there has been an increasing awareness by both the private and public sectors of the ability to improve the quality and safety of healthcare with interoperable healthcare information technology (IT) systems (Markle Foundation, 2003). Some of these health information technologies include electronic health records, personal health records, health information exchanges, evidence-based medicine, and comparative effectiveness (Hersh, 2009). As healthcare systems are increasing the adoption of health IT, a growing amount of data is being gathered. One of the ultimate goals in using health information technology is to evaluate and provide information to providers and patients on the most appropriate treatment options based on scientific comparisons of the effectiveness of treatments, including factors such as quality, risk, benefit, and cost (Congressional Budget Office, 2007).

2.6 Integrating the Healthcare Enterprise

Integrating the Healthcare Enterprise (IHE) is a group of health and health IT organisations responsible for the coordination of the sharing of health information (Wiiting, 2015). The IHE is responsible for the publication of guides for the adoption of health standards and ensuring compliance with those guides. The IHE standards exist in the domains of cardiology, dental, eye care, IT infrastructure, laboratory services, patient care coordination, patient care devices, radiology, research and public health, and mobile access to health documents (https://en.wikipedia.org/wiki/Integrating_the_Healthcare_Enterprise). There

are many benefits that can be derived from IHE (https://en.wikipedia.org/wiki/Integrating_the_Healthcare_Enterprise). When health IT systems are interoperable, medical errors can be reduced, meaning that the safety of data is enhanced and information is exchanged securely and privately. When systems are integrated, the readily available information facilitates informed decision-making. There is access to information on patients’ medical history from any institution. Clinicians have a complete view of a patient’s history regardless of where the patient has presented for care. On the other hand, there is a proper flow of information from one health institution to the next. As a result, silos in the sharing of information are broken down when more effective workflows are obtained. At the same time, timely presentation of up-to-date clinical information is achieved

The benefits of IHE for ambulatory services is that patients can easily be referred to other service providers. The benefits of IHE to government is in the easy monitoring of public health. The benefit to vendors is that they can streamline their product development cycles by leveraging this integration capability across multiple customers.

Enabling interoperability of electronic health records is guided by health standards referred to as IHE profiles. In these profiles, use cases describe scenarios on how technical specifications of information can be structured and shared in a uniform way and the data in any documents can be exchanged in the profile. Therefore, the solution to any particular problem is solved through the use of such profiles. An example of such a profile is the Health Level Seven standard (HL7). The profiles range from standards for the electronic exchange of healthcare information related to pharmacy services, to standards for transmitting medical images between servers, scanners, work stations, printers, networks and picture archiving from multiple systems, standards for identifying health measurements, observations and documents, standards for identifying and promoting voluntary internet standards, standards for the development, convergence and adoption of standards for security, standards for the development and publishing of voluntary consensus technical standards for a wide variety of products and services, and many more. Profiles taken together make up what is called a Standards-based Framework for Health Information Sharing. The IHE Infrastructure Framework defines specific implementations of established standards to achieve integration goals that promote appropriate sharing of medical information to support optimal patient care.

2.7 HL7 Standard

Health Level Seven (HL7) is a Standards Developing Organization (SDO) that provides standards for healthcare interoperability. HL7 is the global authority that defines standards for interoperability of health information technology (Shaver, 2007). In extremely general terms, HL7 is a messaging standard that enables clinical applications to exchange data. In the healthcare “every user and setting is a unique” world, hence data exchange can be challenging. Patients may believe a radiology information system (RIS), lab information system (LIS), hospital information system (HIS), and electronic medical record (EMR) inherently communicate with one another seamlessly (Shaver, 2007). Furthermore, they may expect information to be sent freely between a hospital and external magnetic resonance imaging center or external testing laboratory, for example. However, in many cases, each of these systems speaks its own language.

In 1987, in an attempt to begin solving this problem, an international community of healthcare subject matter experts and information scientists collaborated to create the HL7 standard for the exchange, management, and integration of electronic healthcare information. Today, HL7 is a standard developing organisation accredited by the American National Standards Institute (ANSI) to author consensus-based standards representing a broad view from healthcare system stakeholders (Shaver, 2007). From a practical standpoint, the HL7 committee has compiled a collection of message formats and related clinical standards that loosely define an ideal presentation of clinical information. Together, the standards provide a framework in which data may be exchanged. After years of work, the HL7 messaging standard is used worldwide and is still being modified to meet the changing data needs of the healthcare world. This standard does not dictate to hospitals, medical clinics, imaging centers, labs, and software vendors how to build applications or present data. Rather, HL7 was created as a framework for negotiation where an agreed-upon ANSI standard would be used to enable independent systems to communicate with one another (Shaver, 2007). That is, the standard is the basis of data exchange. The HL7 standard is often called the nonstandard standard. While not entirely fair, it does reflect that almost every hospital, clinic, imaging center, lab, and care facility is “special” and, therefore, there is no such thing as a standard business or clinical model for interacting with patients, clinical data, or related personnel. Just as programmers utilise the broad capabilities of Java, Visual Basic, C++, and XML to solve their specific needs, HL7 offers a broad messaging standard that can accommodate both large-scale hospital networks and stand-alone diagnostic imaging centers and clinics. To clear up a common misconception, HL7 is not a software application. The title HL7 conjures images of a packet of compact discs, manuals, and clever icons. This could not be further from the truth. In reality, the HL7 standard is a “book of rules” with thousands of pages of detailed interfacing information that sets forth a framework for negotiation in interfacing, giving programmers and analysts a starting point from which to begin their technical discussions.

There is a need for integrated systems to allow doctors to be connected with each other especially during transfer of care (HIMSS, 2012). Moreover, doctors need to be connected with pharmacists to reduce harmful errors; hospitals need to be connected with each other specifically for medical record transfer. Founded in 1987, Health Level Seven (HL7) international with members in 55 countries is a not-for-profit, ANSI-accredited standards-developing organisation. HL7 is dedicated to providing a comprehensive framework and related standards for the exchange, integration, sharing and retrieval of electronic health information that supports clinical practice and management, delivery and evaluation of health services “Level Seven” refers to the highest level of the international organisation for standardisation (ISO) communications model for open systems interconnection (OSI) – at the application level. The application level addresses definition of the data to be exchanged, the timing of the interchange, and the communication of certain errors to the application. The seventh level supports such functions as security checks, participant identification, availability checks, exchange mechanisms negotiations, and most importantly, data exchange structuring.

2.8 Health information systems

The wide spread use of information and communication technologies (ICTs) has permeated almost all aspects of life including the healthcare sector. The intersection between healthcare business processes and information systems to deliver better services is popularly known as health information systems (HIS) (Anshari, 2011; Tossy, 2014). According to White (2015), HIS is the organisation of people, institutions, and resources to deliver healthcare services to meet the health needs of target populations. Healthcare systems encompass all organisations, people and factions whose primary intent is to promote, restore or maintain health to ensure that health information is made available to the general public. The use of HIS is important because they help societies to access healthcare information. The WHO (2008) report articulates that health systems are defined as comprising of all the organisations, institutions and resources that are devoted to producing health-related activities. A health activity is defined as any effort, whether in personal healthcare, public health services or through intersectional initiatives, whose primary purpose is to improve health. Furthermore, the use of HIS can allow health service providers to promote, restore or maintain health through healthcare systems technologies.

Healthcare information systems are also referred to as relationships between people, processes and technology to support operations and management in delivering quality healthcare services (Tossy, 2014). Additionally, Tossy (2014) notes that a healthcare information system is a set of components and procedures organised with the objective of generating information which will improve health care management decisions at all levels of a health system. They are used in healthcare to devise, execute, and measure health interventions which have reliable data and performance of different parts of the health system (WHO, 2004). Moreover, WHO (2004), defines a health information system as a system that integrates data collection, processing, reporting, and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services.

According to Hua and Herstein (2003), a health information system (HIS) is a system that integrates data collection, processing, reporting and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services. Despite the credible use of HIS for evidence-based decision making, countries with the highest burden of ill health and the most in need of accurate and timely data have the weakest HIS and the vast majority are the world's poorest countries.

A health information system (HIS) is a system that integrates data collection, processing, reporting, and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services (WHO, 2004). There is a need to balance the demand for health services with resources available and still achieve optimum outcomes, namely a healthy population. Today's healthcare needs to be team-oriented, technology-facilitated informatics supported and evidence-based in accordance with modern scientific principles (Hovenga, 2008).

According Scantlebury et al. (2017) e-health - the use of information technology for health is increasingly viewed as a tool for transforming the healthcare industry and a mechanism for improving the efficiency, quality and safety of care provided. In recognition of the growing international interest in e-health, since 2010 the Global Observatory for e-Health has maintained an online repository for e-Health related national policies and strategies for World Health Organisation member states.

Information systems (IS) are increasingly important for measuring and improving the quality and coverage of health services (Campbell, 1997; Lippeveld, Sauerborn, Bodart, 2000). The global shift from curative to preventative care, from hospital care to community and public health care, from centralised to decentralised health care from a specific project approach to a comprehensive sectorial approach, has necessitated the restructuring of fragmented HIS into single comprehensive health and management information systems. The restructuring of HIS has become an important trend in the entire developing world since the adoption of primary health care as a global strategy for achieving the 'health for all' goals (Campbell, 1997).

Information and communication technology (ICTs) play significant roles in the improvement of patient care and the reduction of healthcare cost by facilitating the seamless exchange of vital information among healthcare providers. Thus, clinicians can have easy access to patient's information in a timely manner, medical errors, are reduced, and health related records are integrated (Olaronke Iroju, 2013). In addition, Information technology (IT) offers the potential to enable efficient communication to reduce costs, improve quality of care and also is a means to patient empowerment (Sebastian Garde, 2007).

Healthcare organisations are increasingly operating in data-rich and information –poor environments. In today's high-tech era, data is constantly gathered and stored, only to be never used because it is inaccessible, improperly formatted or presented in an irrelevant way. A patient health information, for example, may be distributed over a number of locations and via a number of IT solutions throughout the patient's life (CGI, 2014). Many countries have realised the significance of implementing HIS in the past few decades. Many case studies indicated how deploying HIS is a very complex task and how it has helped healthcare professionals to improve the efficiency and effectiveness of healthcare services upon successful implementation (Gladwin, Dixon, & Wilson, 2003).

Haux (2006) describes systems that process data and provides information and knowledge in healthcare environments as HISs. Hospital information systems are just an instance of health information systems in which a hospital is the healthcare environment as well healthcare institution. Health implementation and integration of HIS is crucial to health service in developing countries (Tossy, 2015). Adoption of HIS in African countries is the greatest potential for improving quality healthcare that offers a series of benefits in healthcare institutions from reducing overall cost, integrated HIS reduce errors and duplication of data and procedures examinations, prescription or referrals, since all health professions have access to all patient records from prescriptions treatment, referrals and so on.

Panerai (1996) points that the quality of healthcare delivery or the effectiveness of health planning and policy making depends on the availability of accurate and timely information to support decision making. Broadly, a HIS is any form of structured repository of data, information, or knowledge that can be used to support healthcare delivery or to promote health development. This definition is of relatively little value though because the term HIS has been widely used to include applications that are not immediately related to health development, such as computerised hospital billing systems. On the other hand, many ISs containing data on environment or socioeconomic determinants of health that can be instrumental to support health policy making are not strictly regarded as HIS. WHO (2008) states that the HIS provides the underpinnings for decision-making and has four key functions; data generation, compilation, analysis and synthesis, and communication and use. The HIS collects data from the health sector and other relevant sectors, analyses the data and ensures their overall quality, relevance and timeliness, and converts data into information for health-related decision–making. The HIS is sometimes equated with monitoring and evaluation but this is too reductionist a perspective. In addition to being essential for monitoring and evaluation, the information system also serves broader ends, providing an alert and early warning capability, supporting patient and health facility management, enabling planning, supporting and stimulating research, permitting health situation and trends analysis, supporting global reporting, and underpinning communication of health challenges to diverse users.

Integrating HIS helps to improve communication between health professionals and the security and confidentiality of patient data and records by giving the health professionals access to summaries of data at all times. As it is believed, health information is crucial for patient/client management, for health unit management, as well as health system planning and management. This means that not only decision makers and managers need to make use of information in decision making but all care providers, including doctors, health technicians, and community health workers (WHO, 2000). HIS is a source of knowledge that enables decision-makers at all levels of the health system to recognise progress, problems, needs, make evidence-based decisions on health policies and programs, and optimally allocate scarce resources all of which are key elements in the success of large scale efforts to achieve health improvements. Furthermore, health institutions need to improve the efficiency and quality of healthcare delivery through the development and implementation of a standardised and sustainable integrated HIS which will contribute to form a national Health Information System. HIS will be equivalent to bringing patient expectations and alignment of IT in actual healthcare services.

The following are some of the benefits identified:

- *Reduces costs* – integration of health information helps to reduce costs by eliminating unnecessary duplication of effort at the same time improving healthcare delivery by automating processes so that employees can work more efficiently. They enable system components to communicate with all other components and this speeds up the flow of information (Al-saddique, 2018).
- *Encourages information exchange* – implementation of integrated HIS hold the potential to improve the incentives for providers to share information. HIS is believed to increase the sharing of information on which treatment works best

  by providing administration efficiency, although information sharing is not widely used in Namibian health institutions (Tsiachristas, 2016).
- *Increases quality healthcare services*- advocates believe electronic recordkeeping of patient and health worker data could improve the quality of healthcare (Transitions & Coalition, 2010). HIS gives health practitioners the ability to store and manage their own records securely online. Consequently, it allows patients and doctors to have access to medical records. Remote accessibility of patient

medical histories could help facilitate coordination of care among different health care providers. Other HIS advocates also believe that HIS has potential to boost quality in healthcare by reducing medical errors (Tossy,2015).

- *Reduces errors and redundancy* - HIS interoperability helps to reduce errors and redundancy in medical records. Robert (2008) also argues that HIS would reduce redundant medical imaging and laboratory tests.

Improves patient outcomes –preliminary evidence from different researches assisted in proving how HIS helped healthcare providers save patients' lives by providing a way of communicating between the patients and medical doctors, providing better access, elimination of repetition of tests/visits. Sometimes a patient just wants to pose a simple question but has to walk to the doctor's surgery. Therefore, to ensure that patient outcomes are improved, providers need to learn how to use the technology effectively. The use of ICT in healthcare organisations has grown in the same pattern as compared to the large industry landscape. The use of web technology, database management systems and network infrastructure are part of ICT initiatives that affect healthcare practice and administration. HIS development and implementation in healthcare started in the 1960s and 1970s. The 21st century witnessed a wide range of HIS implementation efforts in both developing and developed countries. Such rapid implementation is facilitated by the nature of the healthcare industry being dynamic. Healthcare industry dynamics are influenced by economic, social, political and technological factors. Moreover, healthcare is undergoing a paradigm shift, moving from industrial age medicine to information age healthcare (Tossy, 2014). As a result, this is shaping healthcare systems and transforming the healthcare patient relationship. All these factors force countries to adopt HIS in order to keep improving their services. HIS is crucial for addressing healthcare challenges and improving healthcare delivery services (Tossy, 2014). The deployment of HIS helps healthcare professionals improve the effectiveness, efficiency, and decision making in the healthcare services.

HIS is made up of various applications such as person management, scheduling, order management, clinical documentation, pharmacy information systems, laboratory information systems, and radiology information systems, just to mention but a few (Salleh,2015). These applications consist of infrastructure, organisations, workforce and components for the collection, processing, storage, transmission, display, dissemination and disposition of information in the healthcare system (Batya & Achimugu, 2010). HIS applications are also used by decision makers to generate “current” health status information and identify potential threats and vulnerabilities in the healthcare systems. Moreover, many publications have positive reasoning on the use of HIS to support health professionals in their bid to make informed decisions. HIS is a source of knowledge that enables decision-makers at all levels of the health system to recognise progress, problems, and needs to make evidence-based decisions on health policies and programmes, and optimally allocate scarce resources all of which are key elements in the success of large scale efforts to achieve health improvements.

Furthermore, health institutions need to improve the efficiency and quality of healthcare delivery through the development and implementation of a standardised and sustainable HIS which would contribute to the formation of a national health information system. HIS would be equivalent to bringing patient expectations and the alignment of IT into actual healthcare services (Haux, 2006). However, sound and reliable information is the foundation of decision-making across all health information systems building blocks, and reliable information is the foundation of decision-making across all health information systems building blocks. Therefore, this is essential for health information systems policy development and implementation, governance and regulation, health research, human resources development, health education and training, service delivery and financing. In the same way, a Health Grid is defined as an awareness programme that can allow the gathering and sharing of many medical, health and clinical records/databanks maintained by disparate hospitals, health organisations, and drug companies(HealthGrid,2015). In other words, a health grid is an environment in which data of medical interest can be stored and made easily available to different actors in the healthcare centres, administrators and of course, patients and citizens in general.

HIS is transforming healthcare in developing countries by improving the quality of care. It has significantly facilitated information access, enhanced workflow, and promoted the evidence based practice to make informed and effective decisions directly at the point of care (Tariq, 2011). It has dramatically improved the decision-making and production processes of health and healthcare by ensuring the right information to the right person and at the right time. Hence, HIS refers to “the application of information processing involving both computer hardware and software that deals with the storage, retrieval, sharing, and use of health care information, data, and knowledge for communication and decision-making" (Tariq, 2011, pp. 2129-2140). HIS can help to access the information about patients, medications, and care processes, organise them, identify links between them and provide them at the point of care delivery; thus improving the care quality. Care practitioners sometimes forget to apply the information familiar to them at the time of delivering care. Thus, the effectiveness of HIS is to straddle the gap between 'knowing' and 'doing' by presenting the relevant information to the clinician at the time of decision-making.

2.9 Health information systems in Namibia

HIS in developing countries have in recent years received significant attention by both healthcare practitioners and the information systems (IS) research community. It has been mainly promoted from the increasing efforts by governments, international agencies, NGOs and other development partners seeking to improve healthcare services through various interventions and approaches (Nyella, 2009). HIS is perceived as a tool for monitoring and the evaluation of health interventions, and to measure progress towards set goals and targets. To achieve the health for all goal, various developing countries like Namibia are pursuing an integration strategy for the fragmented HIS systems within the same country. While some developing countries are managing, some like Namibia are still struggling to adopt silo systems integration. Even those developing countries that at least managed to implement fragmented HIS initiatives are unable to meet their people's needs. The same applies to Namibia. It has proven difficult to fully implement and reap its benefits. Regardless of different efforts going on and different donors' (such as the Global Fund, the United Nations agencies, the World Bank, etc.) emphasis on the importance of HIS adoption, little has been achieved so far. The MoHSS in Namibia has been struggling to adopt HIS without much success (Nyella, 2009). Most of the contemporary research in HIS integration focused on the challenges in the process of achieving integration. Many studies have been mainly on the integration of multiple reporting channels within each program such as malaria, TB, HIV/AIDS, etc. There is however a lack of research and studies on health information integration and increasing fragmentation across the collection of information systems. Therefore, this research addressed the major challenges and constraints of integrating of health information to the public hospitals in the Namibian healthcare sector.

It is stated that HIS can help in the administrative processes in the healthcare sector. Health promotion is defined as an ongoing “process of enabling people to increase control over, and to improve, their health through health system technologies”, emphasizing the need to close the gaps of health inequities within and between hospitals and to advocate social justice (CDC, 2014). Under these circumstances, the purpose of Namibia’s MOHSS implementing integrated health information systems is simple and relevant: to contribute to high quality and efficient patient care. This aim is primarily centred towards the patient and towards medical and nursing care. The administrative and management tasks are then needed to support such care. Currently, a number of health information systems were developed, implemented and then integrated to enhance opportunities of sharing and exchanging information that will lead to increased quality and knowledge in healthcare services.

Namibia’s National Health Information System (NHIS) falls under the Primary Care Directorate in the Ministry of Health and Social Services (MoHSS, 2014). It is charged with the responsibility of providing a comprehensive source of data on a large number of health-related indicators. The NHIS was designed to improve service delivery in terms of quality and effectiveness of strategies and to monitor the trends in disease occurrence. In addition, it also provides information for national policy makers, socio-economic and health personnel, as well as the public at large (Haoses-Gorases, 2015). The organisational structure of the NHIS system is fragmented across different directorates and institutions. The challenges to the system are that there is a shortage of human resources to coordinate, analyse, and report on the information in a comprehensive and timely fashion. In the Namibian health environment, a large number of systems, databases, and processes are fully manual, paper-based, or only partially electronic, and to a large extent formats are either fragmented or nonstandard. This adds significantly to work burdens and seriously undermines efficiency. The Namibian HIS as a routine health and management information system was first introduced in Namibia in 1992 (Thorsen, 2009). The Namibian HIS was tasked with the responsibility of collecting routine data from all health facilities, that is, 36 hospitals, 281 clinics, 33 health centres and a number of outreach points The raw data is collated, analysed and processed into information that can be used for programme planning, implementation, evaluation and can also influence changes in policies, strategies, programmes and resource allocation. This system of collecting information is usually passive.

Due to a lack of standardised automated reporting mechanisms, most reports and templates (including data submissions) are manually filled in and calculated, making them prone to error and again adding significantly to the work burden; and information/reports display and dissemination are generally in static format (Health services in Namibia-Seen environmental learning information,2001). Infrastructure for both local and wide area information and communication technology (ICT) is either inadequate or totally absent, and a lack of required hardware and software at multiple levels essentially make it impossible to access key current systems such as the human resource information management system (IFMS), the Integrated Health Care management system (IHCIMS), and the human capacity management system (HCMS). This also means that facilities are not properly operational and interlinked throughout the health system.

The Ministry of Health and Social Services has been struggling to adopt semantic interoperability of data without much success. Most of the contemporary research in mobile healthcare development in Namibia focuses on the challenges of achieving adoption and yet the real challenge lies in the development of enabling semantic interoperability for the Namibian healthcare sector.

Major health challenges in Namibia can be attributed to certain weaknesses in the health system, such as MoHSS (2008):

- Inadequate human resources and institutional capacity gaps at leadership level;
- Lack of stewardship and coordination of multiple partners;
- Duplication of structures and functions at all levels;
- Multiple information systems;
- Limited integration of programmes and interventions;
- Outdated policies and strategies for linkages between formal structures and hospitals.

According to Obeid and Raison (2001), Namibia's health system aims to improve and maintain the well-being of its citizens by providing services to:

- Prevent and cure disease
- Rehabilitate those who have suffered illness
- Promote good health

- The allocation of resources
- The performance of different facilities and health workers
- The needs of different communities
- The successes and challenges in different regions

Haoses-Gorases (2015) states that the National Health Information System (NHIS) falls under the Primary Care Directorate, Ministry of Health and Social Services (MoHSS). It was established after Namibian independence in 1990 and is charged with the responsibility of providing a comprehensive source of data on a large number of health-related indicators. NHIS was designed to improve service delivery terms of quality and effectiveness of strategies and to monitor the trends in disease occurrence. In addition, it also provides information for national policy makers, socio-economic and health personnel, as well as the public at large. Haoses-Gorases (2015) further points that the organisational structure of the NHIS system is fragmented across different directorates and institutions. The Management Information System is housed in the Directorate of Planning and Human Resources, MoHSS, which collects data on human resources, health infrastructure, and logistics. However, NHIS is managed by the Primary Health Care Directorate, which collects statistics from the health facilities. The challenges to the system are that there is a shortage of human resources to coordinate, analyse, and report on the information in a comprehensive and timely fashion.

The National Policy on Community Based Health Care (2007) states that the Government of Namibia recognises that health is a fundamental human right of all Namibians and is committed to achieving health for all Namibians. With this in mind, the Government, through the Ministry of Health and Social Services (MoHSS), adopted thePrimary Health Care (PHC) approach for provision of health care services, with Community Based Health Care (CBHC) as a strategy to achieve community participation and involvement in their own health. Communities and civil society are currently participating in a wide range of health related programmes, the most common ones focus on health education, HIV/AIDS, malaria and tuberculosis. They are usually supported by community-based organisations (CBOs), non-governmental organisations (NGOs), faith based organisations (FBOs) and the MoHSS.

Baobab Research & Training Institute (2014) pointed that ensuring the provision of quality health care is one of the most important goals of MoHSS. Lately there has been increased focus on how the quality of care in the public sector can be improved. Therefore, the assessment of the National Quality Management Systems could not have come at a better time as the Ministry is in the process of embarking on a restructuring exercise. The MoHSS is committed to the provision of high quality, integrated, affordable and accessible health care and social welfare services. To date, the ministry has, and continues to implement programmes and projects to provide quality health care to all Namibians and other people seeking such care in this country.

The National Health Policy Framework (2010-2020), states that the Namibia health and social services sector since independence has been guided by the Policy Statement of 1990 and the 1998 Policy Framework. During the twenty (20) years of independence, major progress has been made towards the achievements for health for all people in Namibia. Over this period a number of changes have occurred such as adoption of the decentralisation policy to improve service provision and management by de-concentrating authority to 13 MoHSS Regional Directorates; national level re-organisation to enable support service provision and management; restructuring and re-orientation of the health sector in line with the Primary Health Care approach; orientation of social services from curative and remedial social work to a developmental approach with emphasis on prevention of social ills and empowerment of individuals, groups, and communities; broadening of health financing options through the introduction of user-fees policy at all facilities and an exemption mechanism for the poor in place as well as the introduction of the principle of managed competition in the area of buying-in support services.

Brockmeyer (2012) states that at independence, the health system in Namibia was very fragmented and based on racial segregation and a concentration of infrastructure in urban areas such as Windhoek. Since independence, a number of reforms have taken place. The country has about 265 clinics, 44 health centres, 1150 outreach points, 30 district hospitals, three intermediate hospitals and one national referral hospital as well as various social welfare service points. There are 13 MoHSS regional directorates and 34 districts. The main challenges are HIV/AIDS, tuberculosis, malaria as well the increasing number of child mortality. The health system is the most challenging policy area in Namibia because the country's people are scattered all over the place and the MoHSS has problems reaching the workers in the remotest areas to provide health services.

Khan and Duncan (2012) state that an integrated, unified, and effective health information system (HIS) is essential to upgrade the quality of health service delivery and improve health outcomes. National planning commission (2008) found that the Namibian Ministry of Health and Social Services (MoHSS) has fragmented systems managed by different divisions in different directorates. To better inform the HIS reform effort if the current Government of the Republic of Namibia (GRN), MoHSS recently requested USAID/Namibia's support for a comprehensive HIS assessment.

In Namibia, HIS reports include, amongst others, information on reproductive health, expanded programmes on immunisation (EPI), and national vector-borne disease control programmes, communicable disease control programmes and diseases/conditions seen at outpatient and inpatient departments. The reports also include analysis of routine surveillance data for morbidity and mortality trends over time, by administrative region and/or health district. Furthermore, regional health directorates are supposed to produce reports on "Essential Indicators" on a yearly basis (Namibia private health sector assessment, 2010).

2.10 ICTs for health in Africa

Information and communication technologies (ICTs) have the potential to transform business and government in Africa, driving entrepreneurship, innovation and economic growth (Blackman, 2012). Countries in Africa spend significant amounts of their GDP on delivering health services through systems that are often inefficient, costly and lacking in transparency. Information and communication technology (ICTs) have the potential to transform the delivery of health services across the continent in ways that not only increase efficiency but also improve accountability (Simba, 2006). In an increasingly digital world, there is growing recognition that the health sector must integrate information and communication technologies (ICTs) at all levels, especially at a time when health systems face stringent economic challenges and growing demand to provide more and better health care services, especially to those most in need. ICTs might help improve health conditions in low-and middle-income countries (LMICs) by strengthening disease prevention and management efforts, or through effects on the broader determinants of health (Jimenez-Marroquin Deber, & Jadad, 2014). It is therefore valuable for countries to develop policies that could facilities the adoption of ehealth and guide the use of ICTs toward the achievement of the desired goals.

According to International Health Regulations (2005), achieving international public health security is one of the main challenges arising from the new and complex landscape of public health. Shared vulnerability implies shared responsibility. Strengthening countries' disease surveillance and response systems is central to improving public health security in each country and globally. WHO's unique public health mandate, worldwide network, well established global partnership and long-standing experience in international disease control constitute an exceptional and unique asset for supporting countries in strengthening their capacity and for achieving international health security. In June 2007, when the revised International Health Regulations (IHR) enter into force, the world would also have the necessary global framework to prevent, detect, assess and provide a coordinated response to events that may constitute a public health emergency of international concern. Jahid and Panir (2011) pointed that in this digital age, information and communication technologies (ICTs) are considered to be the ‘catalysts to development’. Many studies demonstrate that information systems (IS) can make significant contribution to the health sector particularly in the primary health care (PHC) in developing countries. However, such studies are insufficient due to the pilot syndrome of HICT projects. Jahid and Panir (2011) argue that the poor and the health professionals are the major targets of health-related millennium development goals (MDGs). But most of the world’s poor (about 75 per cent) and significant numbers of health workers live in the rural areas 84 and often remain in the wrong side of the digital divide. WHO (2010) states that the health information system provides the underpinnings for decision-making and has four key functions: (i) data generation, (ii) compilation, (iii) analysis and synthesis, and (iv) communication and use.

The health information system collects data from health and other relevant sectors, analyses the data and ensures their overall quality, relevance and timeliness, and converts the data into information for health-related decision-making. In addition to being essential for monitoring and evaluation, the information system also serves broader objectives, such as providing an alert and early warning capability, supporting patient and health facility management, enabling planning, underpinning and stimulating research, permitting health situation and trends analyses, orienting global reporting, and reinforcing communication of health challenges to diverse users. Information is of little value if it is not available in formats that meet the needs of multiple users, i.e. policy-makers, planners, managers, health-care providers, communities and individuals. Dissemination and communication are therefore essential attributes of the health information system (WHO, 2010).

World Health Organisation Regional Office for Europe Copenhagen (1998) states that the policy for “health for all in the 21st century”, adopted by the world community in May 1998, aims to realise the vision of health for all, which was a concept born at the World Health Assembly in 1977 and launched as a global movement at the Alma-Ata Conference in 1978. It sets out global priorities for the first two decades of the 21st century, and ten targets that aim to create the necessary conditions for people throughout the world to reach and maintain the highest attainable level of health. It is important to realise that health for all is not a single finite target. It is fundamentally a charter for social justice, providing a science-based guide to better health development and outlining a process that would lead to progressive improvement in people’s health.

2.11 Conclusion

In conclusion, this chapter elaborated more on the background literature of existing materials or related work around healthcare information systems. Also on health information systems in Namibia, interoperability, types of interoperability, semantic interoperability, data interoperability, and challenges of interoperability, and information and communication technologies. Likewise, ICTs for health in Africa, as well as systems integration and interoperability, were elaborated. Besides, Health Level Seven, semantic interoperability, along with communicating disease surveillance data in the Namibian context were equally expounded in this chapter. The next chapter covers critical analysis of related literature.

CHAPTER 3: CRITICAL ANALYSIS OF RELATED LITERATURE

3.1 Introduction

This chapter discusses the empirical study on ICT in health and interoperability of data to enable semantic interoperability of data in heterogeneous health information systems in public hospitals in Namibia. The discussion is achieved through a number of ways which includes explaining the critical analysis of literature around healthcare information systems, health information systems in Namibia, semantic interoperability, and challenges in the interoperability of data. Further, heterogeneous distributed systems, distributed database systems, distributed systems, integration of health information systems, and current health silo systems in Namibia, form part of the discussion. Moreover, integrated health care information systems, district health information systems, picture archiving as well as communication system and electronic patient monitoring system were also deliberated upon.

This chapter additionally describes the topic/purpose/focus, the concept behind the theoretical model, the paradigm/method, the context/setting/sample, the gaps identified and relevance of the literatures to this study. The critical analysis as a chapter clearly elaborates more on how other relates researches were conducted and what methods, techniques were used and where the study was conducted. A past study that was conducted related to the study was on the adoption of semantic interoperability of data in heterogeneous health information systems (Angula & Dlodlo, 2018). This study was similar to the conducted study, nonetheless, the difference is that this study developed a model that would enable semantic interoperability of data in heterogeneous health information systems in public hospitals in Namibia. This study enables silo systems to communicate and exchange data and information with each other. The data were not analysed using the same technique as that of the conducted study and the research approach employed in this study was also different.

3.2 The empirical studies on ICT in health

The study conducted by Microsoft Corporation (2010) was about answering the health ICT challenge on an optimised infrastructure. The study further state that the number one challenge facing healthcare providers and public health and social services agencies is delivering higher quality care to more patients and citizens at a lower cost. In addition, a major obstacle is that the diverse players in the health ecosystem traditionally run their own applications in silos, with no interconnection among these applications. The result is that there is no integrated view of how patient care and citizen health information is delivered across the health ecosystem. Furthermore, the study highlighted that Information and communications technology (ICT) can lead the industry toward an inter-connected health platform by delivering an optimized technology infrastructure that combines traditional, cloud-based, and hybrid computing models. This infrastructure would pull together the disparate parts of the health ecosystem, thereby enabling better care, workforce mobility, and security-enhanced data-delivery models.

The new technology infrastructure would also enable patients and citizens to securely access information to proactively manage their own health. An optimised infrastructure would provide ICT with a cost-effective way to manage systems and ensure security, compliance, and reliability. This goal is achievable using a common management and development platform that provides common identity and incorporates familiar tools and existing technologies; works across virtually all cloud and non-cloud locations; and incorporates capabilities that are specific to health organisations' concerns.

The study conducted by OECD (2010) was about improving health sector efficiency, through information and communication technologies. The study further states that in the health sector there is often no measure of performance analogous to profits for private sector firms. While a non-healthcare business selecting its investments in ICTs might consider only financial return on investment, healthcare is a sector that places an unusual emphasis on non-financial goals. In healthcare, a standardised production process is difficult to identify, and, depending on the care setting, there is considerable variation in how and what outputs are produced, and what type and mix of inputs are used to produce them. For example, if ICT is used by a hospital to raise the quality of care or change the mix of services it provides, the resulting financial costs and benefits to the hospital would depend on how the care is delivered and paid for and the extent of transformation required in workflow and processes. How ICTs are used and the context in which they are used are both critical to maximising potential benefits.

The study conducted by Strortmann (2011) was about scoping global good ehealth platforms implications for sub-Saharan Africa. The study further highlighted that the task gathered global empirical evidence, described, and analysed opportunities and challenges towards designing a generic ehealth platform for sub-Saharan Africa. The purpose of the study was to initiate and support the implementation and sustained operation of national or district eHealth platforms facilitating the access and exchange of patient and other health data towards delivering improved healthcare. The rationale of the study was the observation that in spite of the potential benefits offered by space in supporting applications in the field of health, until today the health sector has seen neither significant utilisation of space technologies nor systematic analyses of needs for space assets. Furthermore, aside from cost considerations, this may be due to health professionals’ limited awareness of space capabilities on one side, and by limited understanding of user needs and regulatory issues by the space actors on the other side.

The study done by Simba (2004) states that information communication technology (ICT) revolution brought opportunities and challenges to developing countries in their efforts to strengthen the health management information systems (HMIS). The study highlights that in the wake of globalisation, developing countries have no choice but to take advantage of the opportunities and face the challenges. Moreover, the study further notes that the last decades saw developing countries taking action to strengthen and modernise their HMIS using the existing ICT. Therefore, developing countries need to make deliberate efforts to address constraints threatening to increase the technology gap between urban minority and rural majority by setting up favourable policies and appropriate strategies. Concurrently, strategies to improve data quality and utilisation should be instituted to ensure that HMIS have a positive impact on people’s health. Potential strength from private sector and opportunities for sharing experiences among developing countries should be utilised. Short of this, advancement in ICT will continue to marginalise health workers in developing countries especially those living in remote areas. The study was done at Muhimbili University College of Health Sciences.

The purpose of the study done by Nilsson (2012) was to elucidate experiences of needs of middle-aged people with serious chronic illness living at home and the use of information and communication technology (ICT) as a tool for support from district nurses (DNs) in home care. The study included five papers, a systematic literature review, which comprises both qualitative and quantitative studies, and four papers that take qualitative approaches. Data were collected via focus group discussions (FGDs) with 19 DNs and analysed with qualitative content analysis. The study used a case study design and included an intervention that made use of ICT. Semi-structured interviews were performed with two people who had serious chronic illnesses and were living at home and with their respective DNs. These interviews focused on the experiences of the ill people and their DNs using an ICT application to communicate. Data were analysed with thematic content analysis. The study findings showed that in the last ten years, the number of published studies on the use of ICT in care at home has rapidly increased. The study was conducted in Sweden.

Another study conducted by Heart and Kalderon (2013) assessed the uses by older adults of technology in general and ICT in particular in order to evaluate their readiness to adopt health related ICT. The theory used was the Theory of Planned Behaviour (TPB), while the methods used to gather data were through questionnaires and survey instruments as sources of data. The total number of participants was 123 for face-to face interviews. The study was conducted in the US. The older adults were found to use ICT based on accessibility of computer and support, age, marital status, education and health. Heart and Kalderon’s (2013) study particularly recognised the use of ICT in the health sector. However, their focus was outlined as “to assess the use of ICT by older adults”, did not specifically cover certain technologies applicable in this context. The study acknowledges the use of ICT in health care. The authors declare and maintain that ICT is seen as the enabler to significantly improve the quality of life in the context of health care.

The study done by Cocosil, Archer, and Yuan (2008) was on the adoption of mobile ICT for health promotion: an empirical investigation. The study aimed at an evaluation of the users’ reasons to accept or resist a mobile information and communication technology (ICT) application for health promotion. Literature and interviews were applicable in this study as sources of data. A one-month experiment exposed participants to a health promotion application, delivered through their cell phones to investigate the factors driving people to use or not to use mobile application devices. The study was based on the Uganda Library services and the availability of healthcare information at the medical school library. The study acknowledged the need for ICT and highlighted the possibility of ICT to transform the healthcare sector. Innovations such as electronic medical records, hospital information systems, intranets, public networks, health decision-support and expert systems, telemedicine and community health information systems have all altered the cost, quality, accessibility and delivery of health care. The study did not pin point the types of ICT that can transform the healthcare sector (the highly sought after tools and the low ranked tools/technologies). Also, the study did not stipulate as to how the technology (ICT) can be implemented, designed or adopted to realise the benefits associated with it. Literature reported various mobile applications where the SMS has been used to send out healthcare related information such as vaccinations and various reminders reminding patients about upcoming appointments.

The study conducted by Avison and Young (2007) considered time to rethink healthcare and ICT. It explored the UK underlying models used in applying ICT to health care. The study explored the success of the UK national health care system on a clinical context and scale, along with the capacity to emphasize interpersonal communication. The study highlighted the fact that investing highly on information systems in health is not a solution to improved healthcare services. Some of the ICT services in healthcare are emails, patient e-booking, e-prescriptions, integrated care records, picture archiving and communication systems, and public health web site. A major and fundamental issue that has been ignored in the processes of implementing and adopting health care systems is that healthcare services are the same as any other application in business. This may not necessarily be true though as healthcare systems are fundamentally different from other sectors. The study has however not suggested a solution to ICT in health predicaments but rather encourages the use of existing models.

Simba (2005) studied the strengthening of decentralised healthcare systems in rural South Africa (SA) through improved service delivery by testing mobility and information and communication technology intervention options. The aim was to show the potential impact of ICT in strengthening the decentralised healthcare system in South Africa (SA). A case study approach was adopted. The paper sought to provide a platform on which ICT systems could be understood as viable solutions and used to reduce transport and communication burdens of healthcare workers within the ambit of the DHS system. Literature reviews as well as secondary data from interviews with key informants and thematics with selected key informants from hospitals was analysed for trends, issues, challenges and opportunities regarding healthcare delivery in rural SA with poor access to basic needs and socio-economic services. An HBC interface which allows the caregivers to send information through to the centres and clinics without making several trips to and from the facilities was built on the USSD protocol. The HBC project demonstrated that ICT can be used to act as an intervention to strengthening the decentralisation of healthcare services. The study reaffirmed the need to understand the context and challenges of implementing ICT systems in developing or in typical rural areas and also reaffirmed the need to tailor-make the ICTs for local conditions/needs.

Omona and Ikoja-Odongo (2006) conducted a study and the purpose of the study included the use of ICT in healthcare information dissemination, accessing information, user profiles, ICT literacy and quality of series and telemedicine. Literature reviews and interviews are applicable in this study as sources of data. Interviews and questionnaires were used to collect data gathered for the study. The study was conducted in Uganda and it assessed the application of information and communication technologies (ICT) in health information access and dissemination in Uganda. The study acknowledged the applications used to disseminate health information. The study built a mobile application since most studies done prior had excluded communities' access to health related information. Literature reported the use and application of ICT in health information access and dissemination in Uganda, and drew the attention of all the stakeholders in the health sector to the need to support and promote ICT as the most effective tool for health information access and dissemination.

MoHSS (2012) conducted a study that produced an inventory of the numerous HIS-related information systems and databases within the MoHSS: an integrated, unified, and effective health information system (HIS) framework. The HIS is the principal entry point for all health and health-related information. However, data are entered through a variety of systems and databases. The study was conducted in the Republic of Namibia. National planning commission (2008) found that the Namibian Ministry of Health and Social Services (MoHSS) has fragmented systems managed by different divisions in different directorates. The study has not initiated the technology platform as a useful tool for health information dissemination. The study acknowledged the use of variety of systems and databases within the ministry.

The National Policy on Community Based Health Care (2007) conducted a study in the Government of Namibia that recognises that health is a fundamental human right of all Namibians and that it is committed to achieving health for all Namibians. The policy lays out the framework to further build, support and sustain capacity at community and household levels by encouraging the community to work in partnership with the Ministry of Health and Social Services (MoHSS) and other related partners in health and development. A multi-sectoral task force group was formed to discuss the need and the process of reviewing the 1992 PHC/CBHC guidelines and it has guided the process for developing this policy. The study was conducted in Namibia and the development of this policy has taken place in a number of stages. The study found out that a huge part of community based health care is the provision of home based care as an essential component of the continuum of care for persons living with HIV/AIDS and other terminal diseases. The study did not suggest a technology useful to share health information to the communities. The study acknowledged the model as useful to achieve health for all Namibians.

Blessing, Maumbe, and Shivute (2011) conducted a study that examined ICT use in health service provision in Namibia. A framework that describes the patterns of ICT use for health services by patients, public and private health service providers was developed. The study interviewed 134 patients and 21 health service providers. The study was conducted in Namibia and this study described ICT applications in health service delivery to patients in the Khomas and Oshana regions of Namibia. Results showed the major factors affecting multiple ICT awareness in the two regions as functional literacy, diverse sources of health information services, age and the educational level of the patients. The study has not suggested a mobile application useful for health information dissemination and the study acknowledges the adoption of ICT in the health care environment.

3.3 The empirical studies on health information systems

The study done by Zhang, Xu, and Ewins (2007) was about systems interoperability for healthcare information systems with web services. The study described the use of a new distributed middleware technology 'Web Services' in the proposed healthcare information system (HIS) to address the issue of system interoperability raised from existing healthcare information systems. With the development of HISs, hospitals and healthcare institutes have been building their own HISs for processing massive healthcare data, such as, systems built up for hospitals under the NHS (National Health Service) to manage patients' records. Nowadays many healthcare providers are willing to integrate their systems' functions and data for information sharing. This has raised concerns in data transmission, data security and network limitation. Among these issues, system and language interoperability are some of most obvious issues since data and application integration is not an easy task due to differences in programming languages, system platforms, database management systems (DBMS) used within different systems. As a new distributed middleware technology, web service brings an ideal solution to the issue of system and language interoperability. Web service has been approved to be very successful in many commercial applications (e.g. Amazon.com, Dell computer, etc.), however it is different to healthcare information system. As the result, web service-based integrated healthcare information system (WSIHIS) is proposed to address the interoperability issue of existing HISs but also to introduce this new technology into the healthcare environment.

The study done by Liu, Li, and Liu (2014) focused on pragmatic-oriented data interoperability for smart healthcare information systems. The study further highlighted smart healthcare is a complex domain for systems integration due to human and technical factors and heterogeneous data sources involved. As a part of a smart city, it is such a complex area where clinical functions require smartness of multi-systems collaborations for effective communications among departments, and radiology is one of the areas highly relies on intelligent information integration and communication. Therefore, it faces many challenges regarding integration and its interoperability such as information collision, heterogeneous data sources, policy obstacles, and procedure mismanagement.

The purpose of Liu, Li, and Liu (2014) study was to conduct an analysis of data, semantic, and pragmatic interoperability of systems integration in radiology department, and to develop a pragmatic interoperability framework for guiding the integration. The study selected an on-going project at a local hospital for undertaking the case study. The project was to achieve data sharing and interoperability among Radiology Information Systems (RIS), Electronic Patient Record (EPR), and Picture Archiving and Communication Systems (PACS). Qualitative data collection and analysis methods was used.

The data sources consisted of documentation including publications and internal working papers, one year of non-participant observations and 37 interviews with radiologists, clinicians, directors of IT services, referring clinicians, radiographers, receptionists and secretary. The study identified four primary phases of the data analysis process for the case study: requirements and barriers identification, integration approach, interoperability measurements, and knowledge foundations. Each phase is discussed and supported by qualitative data. Through the analysis, the study also developed a pragmatic interoperability framework that summaried the empirical findings and proposes recommendations for guiding the integration in the radiology context.

The study conducted by NUST and NHIP (2017) was about Easing healthcare information management. The purpose of the project was to research and develop a health information system that would transform the healthcare paper based medical records to an electronic format. Additionally, the aim of the study was to promote interoperability amongst other health information systems in Namibia and hoped that this would promote effectiveness in service delivery. Among other areas the team identified as significant is the inclusion of functions to supporting health-related data analytics. This was set to assist with warnings regarding possible epidemics, allocation of resources across the country, amongst others.

The study conducted by Boone and Cloutier (2015) was about standards for integration of HIV/AIDS information systems into routine health information systems. Furthermore, the study highlighted that in recent years, there has been a strong push to strengthen national health systems in developing countries. In addition, the WHO (2004) describes a health system as consisting of “all organisations, people and actions whose primary intents is to promote, restore or maintain health” (pp. 13-16). It further elaborates on the six building blocks that comprise a health system: health service delivery; health workforce; health information; medical products, vaccines and technologies; health financing; and leadership and governance.

Moreover, the study developed a framework that highlighted the benefits of integration whereby the participants identified several benefits that they expected from HIS: standard data definitions, uniform recording and reporting forms, protocols for electronic medical records (EMR), protocols for training, greater data use at all levels for day to day management and strategic planning, comprehensive view of health activities national better collaboration among stakeholders, increased efficiencies and reduced costs and improved service delivery quality and better health outcomes.

However, some participants viewed integration from a systems perspective in which the relationship between an HIS and the health system was emphasized. The systems perspective views the HIS as composed of two entities: the information generating process where data are transformed into information for use in planning and management; and the HIS management structure consisting of resources and the organisational rules for the efficient use of those resources. HIS integration, therefore, encompasses more than information processing. It requires stewardship, coordination, and partnerships to ensure the appropriate resources are in place to support integrated data use for day-to-day management and strategic decision-making.

The study done by Mwangi (2011) was about integrating health management information systems for patient referrals: a case study of Kenyatta referral hospital and the Nairobi Metropolitan hospitals. The study highlighted that successful implementation of patient care information systems (PCIS) in healthcare organisations is fundamental. Moreover, in line with United Nations millennium development goal on improving healthcare, there is an urgent need to improve on our health care delivery services through the use of ICTs. The study was focusing on the various challenges that inhibit the successful integration of health management information systems between Kenyatta as a referral hospital and other referring centers. The study was a survey of nine hospitals that refers patients to Kenyatta Hospital in the Nairobi metropolitan area. Data was collected through the use of questionnaires from the health workers (doctors, nurses, clinical officers etc.), hospital administrators/management and the ICT staff in the hospitals. Interviews and observation were also used on selected doctors, hospital administrators and ICT staff to enhance objectivity. The findings of the study uncovered a range of issues, some of which are specifically, related to ICT infrastructure in the hospitals, attitudes of the health workers towards information technology in the referral process, their professional and ethical considerations. The study did not suggest the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

Vital Wave Consulting HIS (2009) carried out a study on health information systems in developing countries. The study further stated that the regions, nations, and communities that comprise the health systems that address those challenges are struggling with limited resources and capability. Health leaders must therefore focus on maximising the value of scarce resources and finding ways to make health systems operate as efficiently as possible. Having reliable data on the performance of different parts of the health system is the only way to devise, execute, and measure health interventions. Successful strengthening of health systems will require relevant, timely, and accurate information on the performance of the health system itself. The goal of a health information system (HIS) is to provide that information. Furthermore, the study employed three principal research techniques to create a comprehensive overview of the HIS landscape. Initially, the team conducted an extensive analysis of secondary literature on health information and interviews with experts in health information systems. Next, the research team conducted a thorough review of secondary sources for 19 countries, including literature reviews and interviews to capture a basic picture of HIS initiatives in each country. Finally, primary research was undertaken in three countries with notable HIS initiatives: Brazil, India and Zambia. Site visits to these countries provided first-hand information on three initiatives of special significance. Though it is an upper-middle income country, Brazil is nonetheless included in this report as it exemplifies certain important characteristics of more advanced HIS development occurring in a developing country and can be a reference point for countries in Africa and Asia.

The study conducted by Flingtorp (2008) was about case study of the health information system in Gaborone. The study stated that developing countries experiences an increasing burden of disease as well as challenges financial and human resources. The purpose of the study done by Flingtorp (2008) was on health information flow and information use in Gaborone, Botswana, an analysis of the simplicity, user-friendliness, overlap, relevance, completeness and effectiveness of data collection tools in the Gaborone district, what this information is used for and how managers use it. The study methodology was through a case study of HIS in the capital area, Gaborone, focusing on selected health programmes data was collected over a 12-week period. Moreover, 10 observations in a total of eight facities and administrations, in Gaborone health district were performed. The study results revealed a diverse and fragmented information flow, differing from programme to programme. The study did not suggest the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia Public hospitals.

The purpose of the study conducted by Lemire, Demers-Payette and Jefferson-Falardeau (2013) was to highlight the factors associated with the dissemination of performance information that generate and support continuous improvement in health organisations. Literature and interviews were used to gather data. A narrative synthesis method was used to iteratively detail explicative processes that underlie the intervention. The study was conducted in Canada. Developing a performance measure and reporting the results to support decision making at an individual level yielded poor results in many health systems. Results showed that dissemination in itself is not enough to produce improvement initiatives. Successful dissemination depends on various factors which influence the way collective actors react to performance information such as the clarity of objectives, the relationships between stakeholders, the system’s governance and the available incentives. The study acknowledged the use of ICT to improve health information dissemination. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Yousef (2010) was to explore the dissemination, broadly considered, of an open access (OA) database as part of librarian-faculty collaboration currently in progress. The Theory of Planned Behaviour (TPB) was used. The dissemination of an online database by librarians was broadly considered, including metadata optimisation for multiple access points and user notification methods. The study was conducted in the USA. Librarians addressed OA dissemination challenges by investigating search engine optimisation and seeking new opportunities for dissemination on the web. The study recognised the use of ICT in the health service delivery. The study has however not pin pointed the mobile technology used to disseminate health information to the communities. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia Public hospitals.

The study done by Zarshenas, Sharif, Molazem, Khayyer, and Ebadi (2014) argues that conditions supporting the dissemination (sharing) of nurses' learning are necessary for school change and organisational learning. Literature and interviews were adopted in this study as sources of data. The paper identified 43 factors that motivate nurses' sharing and 35 factors that restrain their sharing in schools. The study was qualitative in nature. The study was conducted in the USA. The paper posited that in the short-term it may be easier to encourage dissemination by reducing restraining factors than by working to increase motivating factors. The study acknowledged the use of ICT by nurses in the USA in the delivery of health services. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Disseminating and Implementing Evidence from Patient-Centered Outcomes Research in Clinical Practice Using Mobile Health Technology (R21), was to grant applications for developmental research projects on using mobile health technology (mHealth) to facilitate the dissemination and implementation of findings from patient-centred outcomes research (PCOR) into clinical practice. The purposes of this FOA were to develop and evaluate the effectiveness of novel approaches that use mHealth tools to enable the timely incorporation and appropriate use of PCOR evidence in clinical practice. Literature and interviews were used in this study as sources of data. Both quantitative and qualitative methods were used in this study. The study was conducted in the USA. mHealth tools included but were not limited to wireless devices, sensors, software, and cellular phones that are intended to be worn, carried, or accessed by health care providers, patients, and/or caregivers. All applications must also describe how the proposed approach incorporates findings from PCOR studies or systematic research reviews and will advance the dissemination and implementation of PCOR evidence into clinical practice. The study acknowledged the use of health information system to support in the health service delivery.

Education (2016) conducted a study that leads national health training programmes and provides technical assistance and implementation for national health policies, strategies, and guidelines. A framework guideline on health training programmes was developed. Documentation analyses were used as sources of data in this study. The study was conducted since 2003, and I-TECH Namibia has provided technical assistance and training to support this success. The study found out that I-TECH works closely with the University of Namibia and the Ministry of Health and Social Services National Health Training Network. The study suggested a model used to give training programmes to the communities, but the study has not pin pointed the semantic interoperability useful for health information sharing. The study acknowledges programs and provides technical assistance and implementation for national health policies.

Network (2005) conducted a study that sought to strengthen Namibia's health information system, to increase its efficiency and utilisation for health action. An assessment health framework was developed. Household surveys, the routine health service statistics and HIV and TB surveillance systems were the main sources of information on key health indicators such as the health MDGs. The study was conducted in Namibia and was aimed for increased efficiency and effectiveness health information. The study found that key health statistics to monitor progress towards the MDGs are available, largely from household surveys with a strong focus on maternal and child health. The study has however not suggested the technology useful for health information access and dissemination. The study also acknowledged that health information is considered important and considerable efforts are being made to document the levels and trends, with special emphasis on regional inequity.

3.4 The empirical studies on health information system in Namibia

The study conducted by Kapweya (2010) was about health workers' knowledge, attitudes and practices of tuberculosis-directly observed treatment (TB-DOT) in the Grootfontein district of Otjozondjupa region in Namibia. The study further highlighted that in the Grootfontein health district, directly observed treatment (DOT) services, a component of directly observed treatment short-course (DOTS) strategy (whereby tuberculosis (TB) patients take medicine under proper supervision and support) is available at all public health facilities. The purpose of the study done by Kapweya (2010) was to explore and describe health workers' knowledge, attitudes, and practices with regard to DOT. A quantitative, descriptive approach to the study was used. The study has engaged all 110 nurses dealing with TB patients and working in public health facilities in the Grootfontein health district. The study data were collected using a self-administered questionnaires and were analysed using descriptive statistics. The findings of the study revealed that the majority (65%) of the respondents were sub-professional nurses, against 35% who were professional nurses. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

Another study was about public private partnership framework conducted by MoHSS (2014) which stated that the government made significant investments in the development of health care for Namibians. At independence in 1990, Namibia inherited a fragmented health system based on racial segregation. The health systems' financial, physical and human resources were ill-distributed geographically, by level and type of service provision resulting in a concentration of infrastructure and services in the urban areas.

The study further highlighted that since independence, there was greater access to health facilities in Namibia due to the increased numbers of health facilities from 246 in 1990 to 346 in 2012. Furthermore, the study stated that to meet the greater challenges and demands made to the public health system, efforts should be made to sustain and maintain the investments made. However, all facilities must have the means to ensure that both the equipment and infrastructure are in good working condition and there is adequate staff to provide quality health services. For instance, the provision of medicines should be in line with the health needs of the people.

The study conducted by Nghitukwa (2010) was about injury surveillance at an intermediate hospital in Windhoek. The purpose of the study done by Nghitukwa (2010) was to explore and describe the demographic profile of patients admitted with injuries in Katutura State Hospital during 2006 as well as the type and quality of interventions these patients received. Furthermore, the study was quantitative in nature, exploratory and descriptive in nature was conducted to provide a baseline information with regards to the topic as it is relatively new in Namibia. The study results highlighted that, the intermediate hospital deals with non-fatal injuries, especially stab wounds. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Tuhandeleni (2016) was about ‘A health information system to Automate patients ‘record: A case of wanaheda clinic, Windhoek’. The study highlighted that with the advancement of information technologies and systems, patient records can be stored in databases, resulting in a positive impact on patient care and elimination of manual systems. Further, the purpose of the study conducted was to recommend a health information system which is unique to Wanaheda Clinic and which would assist the clinic to reduce data duplication and streamline its processes. The study was qualitative in nature which engaged nurses, doctors and on the hand questionnaires were distributed to the participants. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Baobab Research & Training Institute (2014) was about the assessment of the national quality management systems used to monitor and improve quality in health. The study stated that the provision of quality health care is one of the most important goals of the Ministry of Health and Social Services (MoHSS). Lately there has been increased focus on how the quality of care in the public sector can be improved. Therefore, the assessment of the National Quality Management Systems could not have come at a better time as the ministry is in the process of embarking on a restructuring exercise. The study assessment was a key source of information in tackling of quality care issues which are close to my heart, and indeed the hearts of many Namibians. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Mabhiza (2016) was about an investigation of the information seeking behaviours of veterinary scientists in Namibia. The study done by Mabhiza (2016) was an explanatory sequential mixed method research design study that examined information seeking behaviours (ISBs) of veterinarians, laboratory scientists, veterinary hygiene inspectors, animal health and laboratory technicians in Namibia with a view to determine their information needs, information source preferences, familiarity with Directorate of Veterinary Services (DVS) information systems and Ministry of Agriculture, Water and Forestry (MAWF) library services, respondents` adoption of internet technologies, and barriers to information-seeking. The study was quantitative in nature. Furthermore, quantitative data was gathered through surveys from 62 conveniently sampled respondents. Completed questionnaires were coded, and a dataset created using SPSSv20. Descriptive statistics were used to analyse quantitative data. Qualitative data was gathered through semi-structured interviews held with 7 purposively sampled key informants in phases. Voice-recorded data was transcribed, then coded, and organised into groups of related themes. Thematic analysis was used to derive meaning out of data. The study findings showed that respondents had various information needs: emergency problem solving; laboratory tests and experiments; literature review; preparing for meetings and conferences; continuing professional development; and information on drugs. Informal sources, such as personal notes and colleagues were more popular among respondents. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The MoHSS is committed to the provision of high quality, integrated, affordable and accessible health care and social welfare services. To date, the ministry has, and continues to implement programmes and projects to provide quality health care to all Namibians and other people seeking such care in this country. The assessment was made possible with the technical and financial assistance from the United States Government President's Emergency Plan for AIDS Relief (PEPFAR) through the US Department of Health and Human Services (DHHS), Centres for Disease Control and Prevention (CDC). The funding helped the ministry to outsource the study to Baobab Research and Training Institute, a local institute based in Namibia. It is comprehensive and was conducted in 41 health facilities including all 34 public hospitals, 2 selected private hospitals and 5 health centres. It is the first of its kind in the country and was intended to critically assess the quality of health care across the entire ministry, in a structured and systematic manner. The Assessment Report provides a clear picture of the issues dealing with quality health services. It highlights the challenges facing the provision of quality health care. Notably, it identifies a general lack of a common standard understanding of what quality and quality assurance in health care means. The report reveals a high fragmentation of quality of care programmes and their poor coordination. The Assessment Report provides constructive recommendations on how the MoHSS can improve the quality of its care through better quality management systems at all levels. It recommends strengthened policy and strategic plans on quality management, creation and use of standardised terms and terminology on what quality is and suggests the development of strengthened quality indicators to help standardise the monitoring of performance across various health facilities. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

These efforts would create a culture of quality care provision, and extend quality monitoring to many other priority health care services whose quality has hitherto not been monitored systematically. Most importantly, the report demands that the promotion of organisational values and their internalisation by staff should be the MoHSS leadership's core business and that leaders should create a quality care culture. During the 2013 annual meeting with the ministry's management cadre, it was reiterated that the commitment to support quality improvement programmes for all health professionals and most important the provision of quality health care to the key stakeholders, the patients. The findings from the study highlighted where they had done well and pointed to the necessary systems in place. Despite limited human resources, most staff were trying their utmost to ensure that quality is adhered to at all times and at all cost.

Adams (2006) conducted a study that addressed some key management issues relating to developing mobile support for community healthcare (CHC) provision, such as support structures, service management and organisation. A framework was developed relating to developing mobile support for community healthcare. The paper presented three generic examples that drew out of the heterogeneous nature of CHC support and the issues and challenges involved. The research is mostly qualitative, based on interviews with key health and social care professionals in the south of England, supported by desk-based activity. The study was conducted in the United Kingdom. From the study it is clear that many CHC professionals, for the generic case examples, cannot do their community activities without some mobile technology support, such as a mobile telephone. The study though has not highlighted how mobile phones can be used to disseminate health information to the communities. The study acknowledges the use of mobile phones to provide service management to organisations. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

Furthermore, van Dyk (2014) provided a conceptual framework along with underlying propositions for the design and deployment of telemedicine projects which provide healthcare organisations with strategic benefits. A conceptual framework was developed. Field research was conducted at four healthcare organisations. Literature in the areas of telemedicine and process management formed the basis for the conceptual framework and propositions provided in this paper. The study was conducted in the United States of America, and the conclusion reached was that telemedicine can be used as a process enabler for enhanced healthcare-delivery systems. The study has however not highlighted how communities in the United States of America receive health related information even though the study acknowledges the use of ICT in healthcare.

Moreover, Alharbe, Atkins, and Champion (2015) conducted a study that outlined the results of a study of the potential use of sensor technology such as radio frequency identification (RFID) and/or ZigBee technology in providing real-time tracking and tracing of patients and equipment in hospitals. A framework was developed to provide real-time tracking and tracing of patients and equipment in hospitals. The study was conducted in Saudi Arabia. The study proposed a smart hospital management system that can be used to detect, locate and monitor patients and track assets and equipment using modern sensor technologies in a real-time environment for e-health systems in Saudi Arabia. However, the study has not pin pointed how communities in Saudi Arabia access health related information through mobile applications. The study, however, acknowledges the use of sensor technology such as radio frequency identification. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

Furthermore, Kaewkwungal et al. (2010) conducted a study that assessed the application of cell phone integrating into the health care system to improve antenatal care (ANC). Information systems theory was used. A module combining web-based and mobile technology was developed to generate ANC/EPI visit schedule dates. The study was conducted in Kenya. A module improved ANC/EPI coverage in the study area along the country. The study has however not pin pointed the mobile application used to disseminate health related information even though the study acknowledges the use of ICT in health care.

Shops project (2012) conducted a study that focused on increasing availability, improving quality, and expanding coverage of essential health products and services in family planning and reproductive health, maternal and child health, HIV/AIDS, and other health areas through the private sector. A framework was developed to improve the quality of essential services. Shops project (2012), conducted a review of available published and grey literature pertinent to the assessment's objectives. The study was conducted in Namibia, and the aim was to improve quality and expand coverage and essential health services. As of 2010, Namibia's private health sector had mounted a strong response to HIV/AIDS and the nation's orphans and vulnerable children. The study has however not suggested a mobile application useful to disseminate health information even though it acknowledges that the use of ICT in healthcare can improve the quality of healthcare. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Haoses-Gorases (2015) found that to assess the National Health Information System (NHIS) in Namibia in order to improve service delivery in terms of quality and effectiveness of strategies and to monitor the trends in disease occurrence is a critical factor in the Namibian health sector. Literature and interviews were applicable in this study as sources of data. The study was conducted at the University of Namibia. The organisational structure of the NHIS system was fragmented across different directorates and institutions. The management information system is housed in the Directorate of Planning and Human Resources, MoHSS, and it collects data on human resources, health infrastructure, and logistics. The Haoses-Gorases (2015) study particularly recognised the use of ICT in the health sector. The study has however not pin pointed the types of ICT that can transform the health sector (the highly sought after tools and the low ranked tools/technologies). The study acknowledges the use ICT in health care and Haoses-Gorases (2015) declare and maintain that ICT is seen as the enabler to significantly improve the quality of life in the context of health care. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

3.5 The empirical studies on semantic interoperability

The study done by Taylor (2007) was about provability – based semantic interoperability between knowledge bases and databases via transaction graphs. The study presented a provability-based semantic interoperability (PBSI), a type of semantic interoperability characterised by the ability to express complex relationships between ontologies, and to share information even in situations where information cannot be directly translated from one ontology to another. The study reviewed relevant research in interoperability including languages and ontologies that have been designed to facilitate the exchange of information, as well as techniques for relating ontologies and automating information exchange between them. Work in the Rensselaer Artificial Intelligence and Reasoning (RAIR) Laboratory during a number of interoperability experiments were discussed, with particular respect to a new technique for enabling interoperability. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Stroetmann and Veli (2005) was about towards an interoperability framework for a European e-health research area, locating the semantic interoperability domain. The study was done in Germany. The study identified interoperability and connectivity issues and priorities, barriers and gaps and solution approaches, the study focus on fundamental interoperability issues (identification of actors, organisations, adequate measures to achieve interoperability integration tests and certification). The study further described interoperability as state, which exists between two application entities when, with regard to a specific task, one application entity can accept from the other and perform that task in an appropriate and satisfactory manner without the need for extra operator intervention. On the other hand, the study defined functional and syntactic interoperability as the ability of two or more systems to exchange information (so that it is human readable by the receiver); and semantic interoperability the ability for information shared by systems to be understood at the level of formally defined domain concepts (so that the information is computer processable by the receiving).

The study conducted by Bittner and Donnelly (2004) was about ontology and semantic interoperability. The study highlighted that one of the major problems facing systems for computer aided design (CAD), architecture engineering and construction (AEC) and geographic information systems (GIS) applications today is the lack of interoperability among the various systems. When integrating software applications, substantial difficulties can arise in translating information from one application to the other. The focus was on semantic difficulties that arise in software integration. Applications may use different terminologies to describe the same domain. Even when applications use the same terminology, they often associate different semantics with the terms. This obstructs information exchange among applications. To circumvent this obstacle, the study needed some way of explicitly specifying the semantics for each terminology in an unambiguous fashion. The study suggested that ontologies can provide such specification. Furthermore, the study articulated that it was the study purpose to explain what ontologies are and how they can be used to facilitate interoperability between software systems used in computer aided design, architecture engineering and construction, and geographic information processing.

The study done by Hovenga (2008) was about the importance of achieving semantic interoperability for National health information systems. The study highlighted that every nation's Government would like to have a health system that provides access to all necessary health services for its population, irrespective of location or the individual's financial status. Some countries do this better than others, but shortcomings are everywhere. Some rationing may occur so that only certain ill health conditions can be treated for all, in other instances only the rich or those who are insured or who are in specific locations can access certain treatments. Many national health systems only service ill health episodes and do not invest in preventative care, including public health, occupational health and safety or road safety measures. Most people are not well educated about health so that their lifestyles contribute to high incidences of ill health, and they are not well placed to manage their own health. Despite these shortcomings, population health overall has improved and the world is experiencing longer life spans for most citizens although this varies significantly. In Brazil this has improved from a life expectancy at birth in 2002 of 57 for males and 62 for females to 68 and 75 respectively in 2007. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Iroju, Soriyan, Gambo, and Olaleke (2013) was about interoperability in healthcare, benefits, challenges and resolutions. The study highlighted that information and communication technologies (ICTs) play significant roles in the improvement of patient care and the reduction of healthcare cost by facilitating the seamless exchange of vital information among healthcare providers. Thus, clinicians can have easy access to patients' information in a timely manner, medical errors are reduced, and health related records are easily integrated. However, as beneficial as data interoperability is to healthcare, at present it is largely an unreached goal. This is chiefly because electronic health information systems used within the healthcare organisations have been developed independently with diverse and heterogeneous ICT tools, methods, processes and procedures, which result in a large number of heterogeneous and distributed proprietary models for representing and recording patients' information. Consequently, the seamless, effective and meaningful exchange of patients' information is yet to be achieved across healthcare systems. The study further suggested that the adoption of standardised healthcare terminology, education strategy, design of useable interfaces for ICT tools, privacy and security issues as well the connection of legacy systems to the health network are ways of achieving complete interoperability of electronic based health information systems in healthcare.

The study done by Janaswamy (2016) was on semantic interoperability and data mapping in HER systems. The study hinted that medical data prevents straight forward data mapping, standardisation and interoperability between the heterogeneous systems. The study identifies a specific problem, namely the need to achieve interoperability by applying a standards-based data modelling approach to achieve a common platform that serves to improve the health data mapping of unstructured data and addresses ambiguity issues when dealing with health data from heterogeneous systems. The study proposed an original hybrid algorithm that identifies the attributes of data in heterogeneous systems based on critical medical standards and protocols and then performs semantic integration to form uniform interoperable system. Also efficient data modelling techniques are introduced for improving data storage and extraction. The study tested the proposed algorithm with multiple data sets and compared the proposed approach with traditional data modelling approaches. The study found that the proposed approach demonstrated performance improvements and reduction in data losses.

Sohail, Farhan, Shehzad, Murad, and Kijun (2017) conducted the study in the republic of Korea and Pakistan and the study was about semantic interoperability in heterogeneous IoT infrastructure for healthcare, which highlighted that interoperability remains a significant burden to the developers of internet of things' systems. Furthermore, this is because the IoT devices are highly heterogeneous in terms of underlying communication protocols, data formats, and technologies. The study was developing a model for interoperability focusing on tracking and monitoring of human diseases with respect to prescribed medicine in healthcare domain. Semantic annotations of data using heterogeneous IOT devices. IOT devices are communicating through sensors. The study was an experiment on heart disease dataset (heart disease dataset from center for machine learning and intelligent systems: http://archive.ics.uci.edu/ml/datasets/heart+disease). This dataset is collected from University Hospital, Zurich, Switzerland (Switzerland.data). The study proposed an IoT-Sim model for semantic interoperability among heterogeneous IoT devices in healthcare domain. The main goal of this model was to provide interoperability among heterogeneous IoT devices by using semantically annotated. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

Moreover, the study done by AIOTI (2015), stated that technical interoperability has been the focus of most standards organisations, alliances and consortia for many years and consequently strategies, standards and implementations supporting this level of interoperability are generally available. In addition, semantic technology is essential for integration with each LSP and across LSPs, bypassing the current practices of predetermining all structures before deployment (static data models). The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by American Hospital Association (2015) was about achieving interoperability that supports care transformation. The study highlighted hospitals and health systems around the country have made the transition to using electronic health records (EHRs). Furthermore, the study stated that now that the country has large amounts of health information in electronic form, providers and policymakers are turning their eyes to the goal of ensuring that the data can be easily and securely shared - also known as interoperability. In addition, hospitals and health systems cannot collect and share data across settings of care as easily as they want, to, or without expensive and cumbersome work–arounds. However, at the same time, they face increasing needs to better understand their patient’s conditions and care patterns to successfully manage new models of care such as accountable organaisations. In all endeavours to share information, they must maintain secure systems.

The study done by Murie (2015) was about assessing interoperability between electronic health information systems using a predictive probabilistic interoperability model. The purpose of the study was to determine the feasibility of assessing the level of interoperability between electronic health information systems using a predictive interoperability model and two, to evaluate the applicability of using the predictive interoperability model in the health care context. The method used in that study was a qualitative case study. The study was conducted at the comprehensive care centre in Kapsabet County referral hospital, Kenya. Study participants were identified through purposive sampling. A focus group discussion, interviews, documentation review and direct observation were used to identify the interoperability requirements as described in the meta model, which is a language for interoperability prediction. Data collection process was done within a duration of two months. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The conducted by Esri and Lutz (2013) was about data interoperability. The study further highlighted that data integration brings multiple formats together, data migration is the process of moving data between systems, data cleanup cleans up errors in the data and streamline data preparation, data distribution distributes data to different systems, data merge merges changes from edited data and data validation geometry and attributes.

The study results showed that five electronic health information systems exist in Kapsabet county referral hospital. A pharmacy information system, 2 different electronic medical records systems, a laboratory information system and a national HIS system exists at the study setting. From the metamodel, two predictive interoperability models representing the current scenario (AS IS model) and future scenario (TO BE model) were created. These models were then used to predict for interoperability between health information systems in their respective scenarios. Interoperability between systems in the current system setup was found to be lower compare to the future system setup.

The study conducted by Stonebraker, Brown, and Herbach (1998) was about interoperability ‘Distributed applications and distributed databases: The virtual table interface’. The study highlighted that users of distributed databases and of distributed application frameworks require interoperation of heterogeneous data and components, respectively. In this study, the study examined how an extensible, object relational database system can integrate both modes of interoperability. In addition, software interoperability has many faces. Two of the most important are application and database interoperability. These are the respective domains of distributed application and distributed database technologies.

The study done by Ye (2015) was about semantic interoperability in electronic health record a standardised approach. The purpose of the study was to compare two major international standardisation approaches that enable semantic interoperability in electronic health record (EHR), to identify harmonisation efforts between the two approaches and to suggest possibilities on future harmonisation. Archetypes and HL7 are the two major approaches in current electronic health record development, but their approaches to semantic interoperability are very different. Many countries, organisations, and companies have adopted the overlapping approaches. It is very difficult for systems adopting different approaches to communicate. Harmonisation is one possible way other than replacing each other to settle this issue. The study presented an overview on semantic interoperability in information system, electronic health records and international interoperability standards. The study result suggests that both approaches were sufficient to support semantic interoperability. Despite their incompatibility harmonisation efforts have appeared to alleviate the problem. Further harmonisation is essential and experiences may be adopted from other industries. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Rajabifard (2010) was about data integration and interoperability of systems and data. The study highlighted that interoperability is the capability to communicate, execute programmes, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units. However, in the context of information systems, interoperability is the ability of different types of computers, networks, operating systems, and applications to work together effectively, without prior communication, in order to exchange information in a useful and meaningful way. Moreover, interoperability aims to overcome the inconsistency between diverse systems. In addition, there are different drivers and needs for interoperability including:

- Reduce costly data acquisition, maintenance and processing.
- Provide direct, on-demand access that reduces time and cost. On-demand spatial information means being able to access the desired spatial information in its most current state, with correct representation when we need it.
- Encourage vendor-neutral flexibility and extensibility of products. Vendor-neutral products comply with open standards and are independent from underlying software/hardware
- Save time, money and resources.
- Enhanced decision-making.

Along this line, data interoperability may also be described as the ability to transfer and use data and information in a uniform and efficient manner across multiple organisations and information technology systems. Improving the capability of governments to confidently manage, transfer and exchange information is critical to achieving the benefits of today's societies. There is a need to identify those components that support an environment where information that is generated and held by governments and systems delivering services will be valued, worked and managed as part of national strategic assets. The study further stated that there was a need to develop a framework to provide the principles that underpin sound information management and establishes the concepts, practices and tools that will drive the successful sharing of information across countries.

The study conducted by the European Communities (2009) was about semantic interoperability for better health and safer healthcare. The study highlighted that real-time ehealth systems integrating all relevant information on a patient as well as medical and other health-related knowledge can not only substantially improve collaborative care, patient safety, quality and efficiency of health services, but also support medical and clinical research, training and public health. Moreover, the 'holy grail' of healthcare connectivity is a cornerstone for reaping the full benefits of ehealth. However, to fully realise this goal requires interoperability of such systems within health services organisations and jurisdictions, and across regions and countries. In addition, the European commission has long recognised the need for addressing the multiple levels and complex challenges of interoperability of ehealth solutions. The study further stated that the roots of policy efforts to improve interoperability are grounded in the European ehealth action plan of 2004. The study further pinpointed that the semantic health study applies the following overall interoperability (IOp) definition: Health system interoperability which is the ability, facilitated by ICT applications and systems, to exchange, understand and act on citizens/patients and other health-related information and knowledge among linguistically and culturally disparate health professionals, patients and other actors and organisations within and across health system jurisdictions in a collaborative manner. In this context, semantic interoperability (SIOp) address issues of how to best facilitate the coding, transmission and use of meaning across seamless health services between providers, patients, citizens and authorities, research and training. Its geographic scope ranges from local interoperability (within, e.g., hospital networks) to regional, national and cross border interoperability. The study further stated that the information transferred may be at the level of individual patients, but also aggregated information for quality assurance, policy, remuneration, or research.

3.6 The empirical studies on challenges in interoperability of data

The study done by Telcordia Technologies (2017), was about overcoming interoperability challenges in the internet of things, which clearly highlighted that the inability of today's IoT systems to communicate with each other means that most of the IOT data collected today is not used efficiently and this prevents the IoT from reaching its full potential. The lack of IoT interoperability results in a number of obstacles including: complex integration with silos of isolated data. The study developed a framework overcoming interoperability challenges in the internet of things. The study was not enabling semantic interoperability of data in heterogeneous systems in public hospitals in Namibia.

The study conducted by D Tera Institute (2017), stated that many institutions grapple with technology challenges to access data across systems. Moreover, managing the efficient multidirectional flow of data from internal systems like student information and learning managements, to external educational applications and workforce systems can be difficult when ultimately trying to coordinate the best experience for students and staff to enable success and completion. The study conducted by Byers (2017), states that the internet connects all people –internet of people –IoT- internet of things, interconnection of things or objects or machines, e.g., sensors actuators, mobile phones, electronic devices, home appliances any existing items and interact with each other via internet. Furthermore, the global IOT healthcare market is expected to grow from $32.47 billion in 2015 to $163.24 billion by 2020: remote patient monitoring services, mobile health technology, telemedicine, medication management, improved clinical care employee workflow management and inpatient monitoring. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Cassemiro, Oliveira and Da Rocha (2013) was about towards interoperability between heterogeneous distributed components. The study further highlighted that the popularisation of middleware occurred in recent years promoted the emergence of different technological models. Because of this diversity, interoperability between different models of software components becomes essential to promote the integration of heterogeneous parts. The problems involved with interoperability are treated in general by adopting middleware systems able to mediate and establish communication between different platforms. In this context, this study proposes the InteropFrame, a framework for interoperability between different models of software components (e.g. OpenCOM and Fractal) that aims its extensibility to support other models through the development of plugins. Despite the evolution of middleware technologies with the adoption of component models, it appears that the area of distributed systems presents several barriers for the interoperability between them, and the heterogeneity of middleware platforms is a challenge for distributed programming based on components from different models. Developing software systems for distributed environments that combine different component models is a difficult task. The problem of interoperability between heterogeneous platforms is very complex as it involves dealing with issues related to the differences in distribution models (e.g. a platform can be Object Oriented and another can be a Message Oriented one), session protocols (e.g. a Request-Reply Protocol or a General Inter-ORB Protocol), diversity of services, among others.

The study done by Bhartiya and Mehrotra (2013) was about exploring interoperability approaches and challenges in healthcare data exchange. The study further highlighted that today e-health data and its usage in various dimensions is one of the most discussed issues. The nature of health data is heterogeneous and distributed, accessed through varied formats and architectures supporting different vocabularies. Interoperable electronic Health Record (EHR) systems are the most important enabling tools on the road to patient-centric care, a lifeline for continuity of care and support to mobility of patients. Also, hospitals refer cases to other hospitals located in the same or different cities or countries altogether leading to sharing of information. This generates the reason to study the suitability of available models and protocols enabling exchange of sensitive and time critical health information during open-ended transmission. The issue of sharing data in integrated applications is highly significant and affected by various implicit and explicit factors in terms of technologies and adoption by health providers. Varied architectural approaches are implemented by vendors for designing a HIS (Hospital Information System) without giving any consideration to integrated and interoperable sharing of data. Such disparate systems are best when used in isolation but very weak when tried to talk with each other. The purpose of the study was to review issues-related creation of architectures in the perspective of sharing of electronic health records and the challenges faced by them in an interoperable environment.

The study conducted by Crichton (2015) was about the open health information mediator: an architecture for enabling interoperability in low to middle income countries in South Africa. Furthermore, the study highlighted that interoperability and system integration are central problems that limit the effective use of health information systems to improve efficiency and effectiveness of health service delivery. In addition, an important element of modern solutions to these problems is a health information exchange that enable disparate systems to share health information. The study was a case study approach and uses the development of a health information exchange in Rwanda. Rwandan case study was used to understand and identify the challenges and requirements for health information exchange in low and middle-income countries. The study data was analysed and the architecture was also analysed using the Architecture Trade-off Analysis.

The study done by Lloyd (2017) was about harnessing the power of data in health. Moreover, today across the world, enormous transformation is taking place in healthcare, technological changes are forcing us to reconsider everything about health care, from its delivery to its funding models, from education to scientific innovation and from role of the physician to the role of pharmaceutical companies, payers and patients. With the cost of care on the rise, the industry is experiencing a shift toward preventive and value –based care. At the same time, technology like wearable devices, at –home testing services and telemedicine are empowering patients to be more engaged with and proactive about their own health. Meanwhile, the industry is grappling with the tension between encouraging data sharing to maximise the benefits of data and maintain patient privacy. A focus on data in the coming years has the potential to make health care more preventive, predictive and personalised, meaningfully reduce health care costs and lead to better patient outcomes. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Von, Ingenieurin, and Vega (2011) was about a methodology for automated interoperability testing of healthcare information systems based on an actor emulation approach. The study done by Von et al. (2011) highlights that over the last two decades, the number of healthcare services at the edge of the traditional medical care and computer technologies has increased dramatically, making eHealth infrastructure related services ubiquitous. Furthermore, the study stated that services such as telemedicine, telehealth, Electronic health record (EHR) systems are common terms and practices in the actual medical-care sector. Von et al. (2011) argues that a main characteristic of healthcare information systems (HISs) is that they are very data-intensive systems. In addition, in this respect, a major problem is the lack of product interoperability. Many vendors provide solutions, which are rather provider-centric approaches (i.e., proprietary protocols and message formats), hence, interoperability is not regarded. The study highlighted that interoperability can be evaluated by means of interoperability testing. The purpose done by Von et al. (2011) was to develop an interoperability testing methodology and its realisation concepts for coping with the aforementioned issues (HISs). The developed interoperability testing methodology is demonstrated throughout two case studies.

The study by Lister (2008) was towards semantic interoperability for software systems. The study highlighted that in order to interact and collaborate effectively, agents, whether human or software, must be able to communicate through common understandings and compatible conceptualisations. Ontological differences that occur either from pre-existing assumptions or as side-effects of the process of specification are a fundamental obstacle that must be overcome before communication can occur. Similarly, the integration of information from heterogeneous sources remains an unsolved problem. Efforts have been made to assist integration, through both methods and mechanisms, but automated integration remains an unachieved goal. Communication and information integration are problems of meaning and interaction, or semantic interoperability. This thesis contributes to the study of semantic interoperability by identifying, developing and evaluating three approaches to the integration of information. These approaches have in common that they are lightweight in nature, pragmatic in philosophy and general in application. The first work presented is an effort to integrate a massive, formal ontology and knowledge-base with semi-structured, informal heterogeneous information sources via a heuristic-driven, adaptable information agent. The goal of the work was to demonstrate a process by which task-specific knowledge can be identified and incorporated into the massive knowledge-base in such a way that it can be generally re-used. The practical outcome of this effort was a framework that illustrates a feasible approach to providing the massive knowledge-base with an ontologically-sound mechanism for automatically generating task-specific information agents to dynamically retrieve information from semi-structured information sources without requiring machine-readable meta-data. The second work presented is based on reviving a previously published and neglected algorithm for inferring semantic correspondences between fields of tables from heterogeneous information sources. An adapted form of the algorithm is presented and evaluated on relatively simple and consistent data collected from web services in order to verify the original results, and then on poorly structured and messy data collected from web sites in order to explore the limits of the algorithm. The study results were presented via standard measures and are accompanied by detailed discussions on the nature of the data encountered and an analysis of the strengths and weaknesses of the algorithm and the ways in which it complements other approaches that have been proposed. Acknowledging the cost and difficulty of integrating semantically incompatible software systems and information sources. The third work presented is a proposal and a working prototype for a web site to facilitate the resolving of semantic incompatibilities between software systems prior to deployment, based on the commonly-accepted software engineering principle that the cost of correcting faults increases exponentially as projects progress from phase to phase. With post-deployment corrections being significantly costlier than those performed earlier in a project's life. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Izhar Hussain (2009) was about the role of interoperability in eHealth. The study done by Izhar Hussain (2009) highlights that in the light of challenges the lack of interoperability in systems and services has long been recognised as one of the major challenges to the wider implementation of the eHealth applications. The opportunities and positive benefits of achieving interoperability are eventually considerable, whereas various barriers and challenges act as impediments. The purpose of the study done by Izhar Hussain (2009) was to investigate the interoperability among different health care organisations. The knowledge of this study would be supportive to health care organisations to understand the interoperability problems in health care organizations. In the first phase of literature review interoperability challenges in Sweden and other EU countries were identified. The study used interviews, questionnaires to know the opinions of different medical IT administrator and health professionals. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

3.7 The empirical studies on heterogeneous distributed systems

Nishihara, Moritz, Wang, Tumanov, and Paul (2017) conducted a study in UC Berkeley that described machine learning applications are increasingly deployed not only to serve predictions using static models, but also as tightly-integrated components of feedback loops involving dynamic, real-time decision making. The study was focusing on a new distributed execution framework is needed for such ML applications and propose a candidate approach with a proof-of-concept architecture that achieves a 63x performance improvement over a state–of the art execution framework for a representative application. The study conducted a feasibility study to demonstrate that these API and architectural proposals could in principle support requirements R1-R7. Karatza (2017) conducted a study in Italy about energy efficiency in large scale distributed systems which stated that recent advances in networks and computing systems have led many aspects of our daily life to depend on distributed interconnected computing resources. Large scale distributed systems such as computational and data grids and clouds are used for serving large and complex applications.

The study done by Rajkumar and Swaminathan (2017) was about optimised energy aware scheduling to minimise makespan in distributed systems. The study further, highlighted that in the present world of large distributed systems and energy shortages, energy efficiency has become mandatory. “Makespan” has been the standard optimisation criteria used in scheduling algorithms. Makespan is the time elapsed until all jobs scheduled are completely processed. The study developed an algorithm that try to reduce the overall energy consumption of a schedule in parallel and distributed systems by minimising the idle state times of machines and thereby, keeping the makespan as low as possible. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals. In a heterogeneous distributed database different sites may use different schemas and software, difference in schema is a major problem for query processing, difference in software is a major problem for transaction processing, sites may not be aware of each other and may provide only limited facilities for cooperation in transaction processing.

The study conducted by Godfrey (2009) was about designing distributed systems for heterogeneity. Distributed and networked systems have become highly heterogeneous. Rather than running on clusters or supercomputers composed of identical nodes, today’s distributed systems have wide variation in participants’ failure rates, bandwidth, processing speed, security, and other dimensions. This heterogeneity can result from many factors, ultimately driven by explosive growth of the internet. The study highlighted that modern distributed and networked systems are highly heterogeneous in many dimensions, including available bandwidth, processor speed, disk capacity, security, failure rate, and pattern of failures. Furthermore, heterogeneity can not only be handled, but rather should generally be viewed as an asset. The study introduced a framework, the price of heterogeneity, to model the effect of heterogeneity in parallel and distributed systems. The study results showed a broad classes of systems in which heterogeneity cannot be a disadvantage. The study developed practical methods for distributed systems to adapt to and take advantage of heterogeneity. Addressing heterogeneity in reliability, the study showed that randomisation in node selection strategies typically reduces failure rates—property that permits better understanding of subtle properties of existing systems, as well as the design of new systems.

The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The purpose of the study done by Haub (1999) was to present an innovative concept for user and user access management in heterogeneous network systems in general and the implementation for the distributed object system Dino in particular. The study further highlighted that the main concepts of distributed systems, as well as the main concepts of Dino are introduced in order to state the requirements for a distributed user access management system. An additional aspect that has influenced this thesis is the fact that Dino is meant as a basis for a medical telematics information system. This participation lead to additional requirements. As an example, the Dino system has to reach a high international standard. Therefore, the basics of the new “Common Criteria” were presented. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Pop (2014) was about adaptive resource management in heterogeneous distributed systems. The study stated that in the last few years there has been considerable interest in any domains. Moreover, resource management in distributed systems contributes to ensure quality of services for any type of application. The results were presented in the study refer to cluster computing, grid computing, peer-to-peer computing, and cloud computing all involving elements of heterogeneity. Moreover, these computing distributed systems are often characterised by a variety of resources that may or may not be coupled with specific platforms or environments. The experimental results in the study have been conducted in real-environments or by simulation.

3.8 The empirical studies on distributed database systems

The study done by Huacarpuma, Timoteo, Junior, & Holanda (2017) was about distributed data service for data management in internet of things middleware which stated that sensors have become a regular component of internet of things environment, as well as smart phones and other devices that continuously collect data about our lives even without our intervention. The study used a distributed data service (DDS) to collect and process data for IoT environments. One central goal of this DDS is to enable multiple and distinct IoT middleware systems to share common data services from a loosely coupled provider. The study had used a case study approach to validate its data collecting and querying functionalities and performance, DDS is evaluated in two case studies regarding a simulated smart home system, the first case devoted to evaluating data collection and aggregation when the DDS is interacting with the UIoT middleware, and the second aimed at comparing the DDS data collection with this same functionality implemented within the kaa middleware. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Silberschatz, Korth, and Sudarshan (2005) was on the distributed database. The study articulates that a distributed database system consists of loosely coupled sites that share no physical component. Furthermore, database systems that run on each site are independent of each other and transactions may access data at one or more sites.

The study done by Akoka (1978) was about design issues in distributed management information systems. The study highlights that due to the advances in computer network technology and steadily decreasing cost of hardware; distributed information systems have become a potential alternative to centralised information systems. The purpose of the study was to analyses issues related to the design of distributed information systems. The study further indicated that most of the research study in the past can be characterised by a piece meal approach since it tends to consider the computer network design issue and the distributed data base design issue separately. The study presented a global model in which network topology, communication channels capacity, size of computer hardware, pricing schemes, and routing disciplines are interrelated in an optimal design. In addition, the study showed how to derive from the global model a design model for distributed database systems. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Bailis (2015) was about coordination avoidance in distributed database at University of California. The study highlighted that the rise of internet–scale geo-replicated services has led to upheaval in the design of modern data management systems. The purpose of the study was to demonstrate how to leverage the semantic requirements of applications in data serving, transaction processing, and web services to enable more efficient distributed algorithms and system designs. The study resulting prototype systems demonstrate regular order-of-magnitude speedups compared to their traditional, coordinated counterparts on a variety of tasks, including referential integrity and index maintenance, transaction execution under common isolation models, and database constraint enforcement. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Pang (2015) was about scalable transaction for scalable distributed database systems. The study highlighted that with the advent of the internet and internet-connected devices, modern applications can experience very rapid growth of users from all parts of the world. A growing user base leads to greater usage and large data sizes, so scalable database systems capable of handling the great demands are critical for applications. With the emergence of cloud computing, a major movement in the industry, modern applications depend on distributed data stores for their scalable data management solutions. Many large-scale applications utilise NoSQL systems, such as distributed key-value stores, for their scalability and availability properties over traditional relational database systems. By simplifying the design and interface, NoSQL systems can provide high scalability and performance for large data sets and high-volume workloads. However, to provide such benefits, NoSQL systems sacrifice traditional consistency models and support for transactions typically available in database systems. Without transaction semantics, it is harder for developers to reason about the correctness of the interactions with the data. Therefore, it is important to support transactions for distributed database systems without sacrificing scalability. The study described new techniques for distributed transactions, without having to sacrifice traditional semantics or scalability. The study described a new transaction commit protocol that reduces the response times for distributed transactions and proposed a new transaction-programming model that allows developers to better deal with the unexpected behavior of distributed transactions and lastly, study presented a new scalable view maintenance algorithm for convergent join views. Together, the new techniques in the study contributed to providing scalable transactions for modern, distributed database systems. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

3.9 The empirical studies on distributed systems

The purpose of the study done by Zhu et al. (2017), was to propose ACIA (atomicity, consistency, isolation, availability) as the new standard for transaction support. Essentially, the shift from ACID to ACIA is due to the change of assumed conditions for data management. The study was carried out in China. The study was focusing on making a key observation that the high availability requirement of data has changed the conditions for transaction support. The change of implementation conditions leads to new challenges for transaction support in large- scale distributed systems. The study analysed the challenges regarding each property of ACIA. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Gordon, Paolucci, Grace, and Georgantas (2011) was about interoperability in complex distributed systems. The study states that distributed systems are becoming more complex in terms of both the level of heterogeneity encountered coupled with a high level of dynamism of such systems. Taken together, this makes it very difficult to achieve the crucial property of interoperability that is enabling two arbitrary systems to work together relying only on their declared service specification. The study examined this issue of interoperability in considerable detail, looking initially at the problem space, and in particular the key barriers to interoperability, and then moving on to the solution space, focusing on research in the middleware and semantic interoperability communities. The study argued that existing approaches are simply unable to meet the demands of the complex distributed systems of today and that the lack of integration between the work on middleware and semantic interoperability is a clear impediment to progress in this area. The study outlined a roadmap towards meeting the challenges of interoperability including the need for integration across these two communities, resulting in middleware solutions that are intrinsically based on semantic meaning.

The study done by Armstrong (2003) was about making reliable distributed systems in the presence of software errors. The purpose of the study was to find better ways of programming Telecom applications. The study further stated that these applications are large programmes, which despite careful testing will probably contain many errors when the programme is put into service. The study assumed that such programmes do contain errors and investigate methods for building reliable systems despite such errors. The study has resulted in the development of a new programming language (called Erlang), together with a design methodology, and set of libraries for building robust systems (called OTP). The study further stated that a number of small companies have also been formed which exploit the technology. The central problem addressed by this study was the problem of constructing reliable systems from programmes, which may themselves contain errors. Constructing such systems imposes a number of requirements on any programming language that is to be used for the construction.

Furthermore, the study stateds that problems can be solved in a programming language, or in the standard libraries which accompany the language. In addition, no theory is complete without proof that the ideas work in practice. To demonstrate that these ideas work in practice the study presented a number of case studies of large commercially successful products, which use this technology. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

3.10 The empirical studies on integration of health information systems

The study done by Sheikh (2015) was about health information systems integration as institutionalisation, the case of Zanzibar. The study addressed the question of how to understand and promote health information systems (HIS) integration given the highly entrenched fragmentation of healthcare service provision, a common scenario for developing countries. The study adopted interpretive strand of epistemology, utilising an action research design based on the ongoing action research project to design and implement integrated healthcare information systems (HIS) in Zanzibar, Tanzania. The study adopted a socio-technical perspective of HIS integration, and view integration as a process of institutionalisation of tools (technology) and routines. The study used the circuits of power framework to study the HIS institutionalisation from the lens of power. In doing so the study contributes to the discourse of HIS integration in the context of low resourced settings, contributing both theory and practice. 1) The study reveals the role of status quo in shaping HIS integration, and particular the role of hierarchies and information culture in defining the standing conditions and rules of meaning which members in the healthcare bureaucracy subscribes to, and consequently affecting institutionalisation of the HIS. 2) The study realises the relationship between power and rationality, concurring with previous studies, and extending the findings to incorporate the complexity related to the contextual nature of HIS integration in the context of developing countries. 3) The study responds to the challenge facing IS innovation in the context where power supersede rationalism, and contributes to understanding how technology can play a mediation role in shaping the path of IS in such context. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

Nyella (2006) conducted a study on challenges in health information systems integration that describe the challenges associated with the effort to integrate the HIS in a context characterised by multiple vertical health programmes. The study revealed the tensions that exists between the ministry of health which strived to standardise and integrate the HIS and the vertical programmes. The study was done as part of an ongoing action research on health information system restructuring process undertaken by the health information system program (HISP) in collaboration with the MOHSW and other development partners in Zanzibar/Norway. Case study methodology was drawn upon in the field during data collection and analyses. The aim of the study was to develop a comprehensive understanding of the challenges related to the way users received and engaged with the integrated HIS. Semi structured interview were used, where interviewees were asked open-ended questions to elicit their viewpoints related to the use of the integrated HIS. The integration of the health information system (HIS) involved standardisation of the datasets, data collection tools, data processing tools and associated work practices; and institutionalisation of the standards to the levels of the health system. The study was not addressing the challenges of heterogeneous to enable semantic interoperability of data in heterogeneous systems in public hospitals in Namibia. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

3.11 The empirical studies on current health silo systems in Namibia

The MoHSS is committed to improvements in all these areas and it is currently working on several reforms such as: restructuring the MoHSS; systems integration; improved NHA; and implementing the health extension workers’ strategy. Hence MoHSS (2008) has many stand-alone information systems managed by different divisions in different directorates and running on different software. These systems include the health information system (HIS) which is in primary health care services directorate; social welfare information system (SWIS) which is in the developmental social welfare directorate; management information and research system which is in the policy planning and human resource development directorate; and monitoring and evaluation specialisation in the programmes directorate. This fragmented structure has created overlaps and duplication between the various systems and disparities as resource-strong programmes are able to “push” their own information system agenda. The improvement of the information management system is a high priority for the MoHSS. The National Health Policy Framework 2010-2020 advocates for the integration of parallel resource-strong programme information systems in the mainstream health information system. It also calls for developing and maintaining relevant linkages as much as possible between various information systems, and ensuring the submission of relevant data from the private sector. The national health policy framework 2010-2020 advocates for enabling health workers/health managers at all levels to access and utilize information. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Khan and Edwards (2012) was about the assessment of national health information systems Ministry of Health and Social Services (MoHSS) in the Republic of Namibia. The study pinpointed that an integrated, unified, and effective health information system (HIS) is essential to upgrade the quality of health service delivery and improve health outcomes. The study further stated that the Health and Social Services Review 2008 found that the Namibian MoHSS has fragmented systems managed by different divisions in different directorates. To better inform the HIS reform effort, the current Government of the Republic of Namibia (GRN), MoHSS recently requested USAID/Namibia's support for a comprehensive HIS assessment. The purpose of the study done by Khan and Edwards (2012) was to inventory the numerous HIS-related information systems and databases within the MOHSS; to provide a comprehensive understanding of their content, data elements, associated reporting burden, and how these information systems are used and by whom; and to help identify strengths and weaknesses and therefore formulate recommendations to inform planning efforts. Furthermore, the ministry has also embarked on an aggressive phased approach to fast track the HIS modernisation process under the technical guidance of the TWG. The GRN, along with all other stakeholders, including development partners (DPs), clearly recognise the urgent need for a more unified, integrated, and effective HIS. However, there is still much to be done.

Much of the effort to date has been uncoordinated and directed mostly to isolated technical aspects of the HIS and not to institutional, coordination, and other behavioural aspects. Especially at the national level, until very recently leadership was tentative and uncoordinated and there was too little political support for HIS strengthening. The study assessment team did an extensive document review, conducted 76 group and individual meetings, reviewed 61 systems/database, made site visits, and interviewed over 100 participants. The HIS weaknesses, gaps, and challenges that were identified were grouped below within four broad thematic areas. Each problem must be addressed if the HIS is to serve its purpose of providing reliable and timely information for planning and decision making and supporting day to-day healthcare management on all fronts. Although the assessment was done there was no study done on semantic interoperability of data in heterogeneous systems in Namibia that would allow health silo system to communicate and exchange data with each other.

The study conducted by the World Health Organisation (2017) was about the importance of sexual and reproductive health and rights to prevent HIV in adolescent girls and young women in eastern and southern Africa. The study highlighted that the AIDS epidemic continues to disproportionately affect sub-Saharan Africa, especially eastern and southern Africa (ESA). The study further stated that a growing number of organisations and financing mechanisms as well as national governments are working to respond to this challenge through policy frameworks, programmatic interventions, and funding initiatives specifically targeted to AGYW.

3.12 The empirical studies on integrated health care information systems

The study conducted by OECD (2004), was a report that draws on key lessons from the OECD health care quality review series which stated that as health costs continue to climb, policy makers increasingly face the challenge of ensuring that substantial spending on health is delivering value for money. At the same time, concerns about patient’s occasionally receiving poor-quality health care have led to demands for greater transparency and accountability. The study developed a report that summarises the main challenges and good practices so as to support improvements in health care quality and to help ensure that the substantial resources devoted to health are used effectively in supporting people to live healthier lives.

The study done by Kossi, Saebo, Titlestand, Tohouri, and Braa (2010), was about comparing strategies to integrate health information systems following a data warehouse approach in four countries. The study highlighted that one of the major obstacles of reaching the Millennium Development Goals: inefficient and unreliable information systems. Furthermore, the study articulated that leading organisations have called for integrated data warehouses as one of the solutions, but this remains hard to achieve. The study further highlighted four country cases of standardising and integrating health data, which are all following what, is here termed a data warehouse approach; data from across different health programmmes are organised in one database framework –or data warehouse. In addition, in all countries, fragmentation of health information in different partly overlapping sub-systems run by different vertical health programmes represented a major problem for the efficient use of health information. On the other hand, South Africa developed a new integrated system in addition to the existing fragmented subsystems, Zanzibar, Sierra Leone and Botswana, all aimed to encompass all or most of the data from existing systems. The study was a case study approach with four cases that demonstrated that integration is as much, and maybe more, about aligning organisational political actors as it is about technical solutions. However, the technical solutions are however, important in aligning these actors and in enabling integration. Furthermore, the study stated that attractors, technical solutions or standards that achieve a certain level of success and enable the building of momentum, are important in aligning the various political actors.

The study done by Kostopoulou (2013) was about design and analysis of an integrated health information system. The study highlighted that any form of organisation or business today in order to be able to survive uses computer technology. The rapid evolution of technology combined with the need for easy access to information led to the establishment of Information Systems (I.S.). These systems utilise various sources of information and manage information obtained by principal components such as people, hardware, software and procedures. The performance of systems affects the efficiency, reliability and flexibility of your organisation or business. The information system (I.S.) is finding ever-increasing applications in health care. The purpose of the study done Kostopoulou (2013) was designing and implementing of an electronic health record (EHR). The application is implemented and web-based technologies such as hypertext pre-processor (PHP) and

MySQL. It also includes patient's information in accordance with the traffic and the episodes created during these. It also includes all patient demographics and medical information in concern according to personal history. In the end, it provides medical staff the possibility of obtaining information of a statistical nature. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Nicolescu (2006) was about the integration health networks utopy or reality, the impact of the e-health. The study stated that the principal objective of a health system is to improve health and its principal function is to deliver health care services. Nowadays, hierarchical bureaucracies and fragmented, unregulated markets have serious flaws in the organisation of health care services. A flexible integration of the health providers may mitigate these increasingly important problems. The wide diffusion of technology and the increasing use of information and communication technologies open new opportunities for services and products and consequent business. While technology diffusion penetrated health care services as well, health systems have not known yet had a profound system change. Mechanism and health care provided services are essentially unchanged. Research shows that adopting new technologies into the health care system may constitute an essential condition for imposing change in organising health systems and integrating health care delivery. The study used literature review and case study as methodology study approach.

The study done by Ayele (2015) was about exploring the feasibility of secondary use of patients' clinical-data for clinical research mapping of researchers' clinical-data needs with care providers' account on documented clinical-data in existing information systems at Karolinska Hospital. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The purpose of the study of done by Ayele (2015) was to identify the clinical-data needs and requirements of clinical researchers from available EHR systems, and map their data need with existing EHR infrastructure. The study highlighted that electronic health records (EHRs), augmented with advancements in technology and greater adoption rate, are used in healthcare facilities as an integrated digital repository system to facilitate effective management of patients and care related data. EHRs, promising to provide an ideal form of longitudinal patient health record, offer remarkable and enhanced opportunities for clinical research. A qualitative study design was used to assess the clinical-data needs and requirements of clinical researchers (involved in allergy and asthma, and/or airway research) and to evaluate what is actually documented in EHRs. The study revealed clinical researchers' positive attitudes in reusing EHRs to support and expedite their clinical research and related processes. EHR data quality and data access issues were denoted to impede EHR reuse in clinical research studies. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Clementson (2011) was about the evaluation of integrated health information systems iHIS. The study highlighted that the countries within the Caribbean region are pursuing the development of national integrated health information systems (iHIS). The model of the Belize Health Information System (BHIS) is referenced as the implementation guide. The purpose of the study done by Clementson (2011) was to determine the common approaches for evaluating health information systems (HIS) and applies these findings to formulate an evaluation approach for these regional systems. This approach is intended to strengthen the regional capacity for evaluating national HISs by examining the contextual factors and providing an evaluation tool, CHEATS+, for systems lifecycle evaluation. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

3.13 The empirical studies on district health information system

The purpose of the study done by Foster (2012) was about the review of developing country health information systems, which described the district-wide health information management system (DHIMS). The DHIMS has been developed for use at districts in order to improve the use of health data for decision making at the level where data is produced. It is claimed that the system captures the data in the districts from "the community and public health services to the district hospital'' and provides support for hospital integration of electronic patient records, billing and hospital management system. The study used published literature, web sites of country ministries of health. Communication from individuals exposed to health information systems in the countries. Furthermore, the study done by Van den (2009), Bergh was about the district health information system (DHIS) as support mechanism for strengthening the health care system. The purpose of the study was to show how information from the district health information system can be used to empower managers to make evidence-based decisions that will strengthen the health care system to reduce the under-five mortality rate. A quantitative, contextual, exploratory evaluative and descriptive approach was followed and a data extraction framework, based on systems theory, was developed to guide the process of extracting existing routine data. The study was done in South Africa and the study has highlighted that proxy indicators obtained this way places health care managers in the position to monitor progress towards achieving the millennium development goal for child mortality in the interim periods between large population surveys. Data analysis was carried out by making use of the DHIS software. Although the DHIS software is not a statistical package, it enables analysis since it organises and categorises raw data, it calculates standardised pre-set indicators and displays results in a way that supports meaningful presentation. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Braa (2017)) was about integrated health information Architecture –the DHIS 2 experience –information for decision making and management. The study was based on experience from implementing DHIS over 20 years-in more than 30 countries in

Africa, Asia and Latin America. The study highlighted challenges of multiple ‘silos’ instead of integration and on the other hand systems are overlapping and not ‘talking’ to each other. In addition, no easy access to integrated information for management and decision making at “one point”-at any level. The study pinpointed three levels, the first level was level 1 that deals with information needs, users, usage across organisations “Business level”, level 2 which deals with software applications and information systems “Application level” and level 3 which is about data exchange level “Technical level “interoperability and standards, technical infrastructure.

The study done by Oaikhena (2016) was about adoption and use of electronic healthcare information systems to support clinical care in public hospitals of the Western Cape in South Africa. The study highlighted the prospective benefits that e-health information systems (e-Health IS) offer to support the healthcare sector; there are limitations in terms of usability, functionality and peculiar socio-technical factors. The study stated that healthcare professionals do not make the most use of the implemented e-Health IS. Unfortunately, explanations remain tentative and unclear, yet non-usage of the e-Health IS defeats the objectives of its adoption, in the sense that the plan to improve and deliver quality healthcare service in the public sector may not be achieved as envisaged. The purpose of the study was to acquire explanations to the causes of the limitations regarding the adoption and, particularly, the use (or non-use) of e-Health IS by clinical staff in the public healthcare institutions in South Africa. A deductive approach was adopted for this investigation. The nominalist ontology and interpretivist epistemology positions were taken by the researcher as a lens to conduct this research; which informed a qualitative methodology for this investigation. Purposive sampling technique was used to identify the appropriate participants from different hospital levels consisting of Hospital administrative staff, and clinical staff (clinicians and nurses) of relative experiences in their clinical units. Subsequently, the Unified Theory of Acceptance and Use of Technology (UTAUT) and content analysis technique were used to contextualise, simplify, and analysis the text data transcripts.

The study findings indicated that healthcare professionals have a high level of awareness and acceptance to use implemented e-Health IS. There are positive perceptions on the expected outcomes, that e-Health IS would improve processes and enhance healthcare services delivery in the public healthcare sector. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The purpose of the study done by Mukama (2003) was to explore the procedures, tools and problems related to primary health care data collection, storage use and information flows. The study was also to offer ideas and suggestions on how to improve the systems of routine data collection, storage and analysis and use of information and more generally to improve the flows of information and healthcare information systems. The study employed qualitative research methods, including ethnographic methods; interviews, observations in the health facilities settings, analysis of patient records for varying recording tools and content, reviews of documents, and the analysis of existing computer systems within the health information systems in study. The study was carried out in Xai – Xai district, Chokwe district, Chibuto district and Bilene district in Gaza Province, in Mozambique and Kibaha district in Coastal region, in Tanzania.

The study focussed on the various information flows originating at the local health facility, how the data are collected and stored, use or/and non-use of data, sharing or communication of important information between primary health care and hospital levels, data flows from the health facilities to the districts to the region or province and to the national level.

The study's empirical findings were discussed in relation to the literature review. The literature review ranged from various writings on existing health information systems (HIS) in developing countries, socio-cultural factors shaping the HIS, the role of information and communication technologies (ICT) in health systems in developing countries, and decentralisation of information management toward the district level as a way of restructuring the health information system in the broader process of health sector reform. Through a cross-case analysis of the study empirical data and discussion, the study found that there are several problems related to the use and management of information at local levels within the HIS. To improve the use and management of information at local levels within the HIS the following should be done: Local learning and discussion of essential HIS needs, and the role of routine data collection in meeting those needs. Establishing an information culture in HIS and health care organisations. Investing in health data collection, use and management of health information at local levels within the HIS.

The study done by Harikumar (2012) was about evaluation of health management information systems - a study of HMIS in Kerala. The study further highlighted that health information is the foundation of public health and a well performing routine health management information system is needed to improve evidence-based decision-making and health system performance. The study conducted a formal evaluation of HMIS in Kerala with the specific objective of identifying the technical, organisational and behavioural factors affecting the processes and performance. Methods: The Performance of Routine Information System Management (PRISM) framework and associated tools were used for empirical assessment of the technical, organisational and behavioural determinants, the processes and performance related to HMIS in Kerala. The descriptive cross-sectional study involved 115 respondents from 26 sub-centres, 12 primary health centres, six blocks, two districts and the state level office. Results: The performance measured in terms of proportion of facilities within acceptable limits of accuracy and completeness were low at 37% and 29% respectively.

The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

3.14 The empirical studies on picture archiving and communication system

The study done by Strickland (2000), was about a picture archiving and communication systems: filmless radiology which is a computerised means of replacing the roles of conventional radiological film. The study describes the Hammersmith PACS, and discusses the advantages and disadvantages of PACS systems. The study further highlights that a picture archiving and communication system images are acquired, stored, transmitted, and displayed digitally. When such a system is installed throughout the hospital, a filmless clinical environment results. The PACS database ensures that all images are automatically grouped into the correct examination, are chronologically ordered, correctly orientated and labelled, and can be easily retrieved using a variety of criteria (for example, name, hospital number, date, referring clinicians, etc). The study was conducted in the UK under the Hammersmith Hospital of Imaging, Du Cane Road, London. The study data were gathered from central archive at Hammersmith Hospital.

The study done by done Chen, Bradshaw, and Nagy (2011), the study stated that picture archiving and communication (PACS) market has been transformed by disruptive innovations from the information technology industry. The cost of storage alone has dropped by a factor of 100 within the past 10 years. Improvements in display, processing, and networking have likewise enabled PACS to be a capable replacement for film.

The study done by Alawi, Eid, Ahmed, and Albarrak (2016) was about assessment of picture archiving and communication system (PACS) at three of ministry of health hospitals in Riyadh region-content analysis. Moreover, picture archiving and communication system (PACS) are management information systems used for distributing, viewing and archiving digital images by integrating different types of modalities through communication networks. PACS have many advantages that can lead to improving health care quality. PACS has been widely used in hospitals in Saudi Arabia for the past 10 years. However, an extensive review of literature in the field of PACS, among physicians and radiologists in Saudi Arabia, showed lack of local studies of this costly and newly implemented technology. The purpose of the study done by Alawi, Eid, Ahmed and Albarrak (2016) was firstly, assess the perceived benefits of PACS among physicians and radiologists specifically in quality of care, secondly, assess the perceived challenges of PACS implementation and adoption inside and outside the radiology department, and thirdly, to compare between physicians ‘and radiologists’ perceptions toward PACS. The method used in the study was a cross-sectional descriptive study at three of Ministry of Health (MoH) hospitals in the Riyadh region, Saudi Arabia. The study used two separate surveys questionnaires, for administration to the physicians and radiologists at the three hospitals. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Singh and ErAnkitBansal (2014) was about HIS integration system using modality worklist and DICOM. The study done by Singh and ErAnkitBansal (2014) highlights that the usability and simulation of information systems, known as hospital information system (HIS), radiology information system (RIS), and picture archiving, communication system, for electronic medical records has shown a good impact for actors in the hospital. The purpose done by Singh and ErAnkitBansal (2014) was to help and make their work easier; such as for a nurse or administration staff to record the medical records of the patient, and for a patient to check their bill transparently. However, several limitations still exist on such area regarding the type of data being stored in the system, ability for data transfer, storage and protocols to support communication between medical devices and digital images. This paper reports the simulation result of integrating several systems to cope with those limitations by using the Modality Worklist and DICOM standard. It succeeds in documenting the reason of that failures of future research will gain better understanding and able to integrate those systems. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Modrák and Modrák (2013) was the effect of a PACS on patient radiation doses and operating costs in a radiology department: a practical study. The study was conducted to investigate how the implementation of a picture archiving and communication system PACS affects patient radiation doses and operating costs of the radiology department. The study results indicated the use of PACS was significant in causing differences in the total radiation doses and in operating costs of radiology department. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Fontainha, Martins, and Vasconcelos (2014) was about exploring the determinants of PAS, EDMS, and PACS adoption in European hospitals. The study reported in this paper explores the determinants that lead to the adoption of three of the most commonly used health information systems (HIS) in European hospitals: Patient administration systems (PAS), electronic documents management systems (EDMS), and picture archiving and communication systems (PACS). For statistical analysis and modelling purposes, the original variables in the two surveys were transformed into binary variables. In order to explore the determinants of system adoption, Probit models were built taking into consideration the following explanatory variables or predictors: public ownership; hospital size; and human resources allocated to research and development. It has been found that being a public hospital, particularly in recent years, has a negative impact on HIS adoption. Hospital size is one of the main positive predictors of HIS adoption. The impact of human resources allocated to R&D is also a determinant of HIS adoption, but less so in recent years. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Fridell (2011) states that PACS have been implemented not only within radiology but also within the orthopedic and other healthcare contexts, affecting healthcare services more broadly. To improve the usefulness of PACS in health care, the study needed to understand how it affects different aspects of health care, and the underlying reasons for these changes. The purpose of Fridell's (2011) study was to inform health care management of change processes relating to digital image management and PACS use through an understanding of its effect on professional roles, work practice and technology in use, as well as highlighting accelerators and decelerators in change processes associated with the use of PACS in health care. The study was a longitudinal study with a qualitative approach. Data were collected by means of semi-structured and open-ended interviews. The interviews were transcribed, analysed, and coded using grounded theory as an organising principle. The trends of change in the professional role over time indicate that radiologists shifted from a role which emphasized their individual professional expertise to becoming more of an actor in a network. The findings of the study indicated that at least four aspects of improvisation are key factors in the implementation and use of information and communication technologies (ICT). These factors are vision, time, negotiations and information technology use. It was demonstrated that the work practice in the healthcare process needs to have a vision (direction). In the health facilities in this study, the vision developed into a commitment to enable access to images at “anytime – any place”. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by Hurlen (2010) indicates that Akershus University Hospital introduced information and communication technology (ICT) to its radiology department. Moreover, both images and reports were stored and communicated electronically instead of as printed film and paper. The purpose of the study conducted by Hurlen (2010) was to retrospectively assess whether the introduction of ICT improved diagnostic imaging and health care. In addition, the study was addressed by investigating whether the introduction of ICT made radiology reports available sooner to clinicians, whether they read them sooner, whether this had an impact on the length of patient hospital stay, and whether any improvement in reporting was achieved without reducing the diagnostic accuracy. The study method was a before-after study using two cross-sectional data collections. The study data were partly recorded by health care professionals as part of their daily work, and partly created by automatic logging of their activities. The study supplementary data were collected manually from work lists and routine descriptions. The study data were analysed using the two-sided non-parametric Mann-Whitney U-test for ordinal and the T-test for nominal data. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study conducted by MacDonald (2008) was about evaluating the implementation of picture archiving and communication systems in Newfoundland and Labrador. The study highlighted in November 2007, the Newfoundland and Labrador Centre for Health Information (NLCHI) of a provincial picture archiving and communication system (PACS). The purpose of the study was undertaken to determine the impact that this PACS implementation had within the province of Newfoundland and Labrador. The study evaluation was carried out on the island portion of the province with a focus on 2 of the 4 provincial health authorities. Furthermore, study evaluation was designed as a pre/post-comparative study utilising project documentation, administrative data, surveys and key informant interviews as the primary data sources. The study findings showed that clinicians, administrators and support staff strongly support the implementation of a provincial PACS. The study has not suggested the adoption of semantic interoperability of data in heterogeneous health information systems in Namibia and no study was done in Namibia to enable semantic interoperability of data in heterogeneous health information system in Namibia public hospitals.

The study done by Triegaardt (2013) was about picture archiving and communication systems in the South African public healthcare environment: A suitable structure and guidelines to assist implementation and optimisation. The study highlighted that South Africa has a great number of patients and not enough medical expertise to attend to their patient needs. The study further stated South African Department of Health (DoH) has recognised the potential benefit of the picture archiving and communication system (PACS) to address the health needs of rural patients who do not have access to specialised medical care. PACS allows specialist remote access to patient information to assist the diagnosis and treatment process remotely. South African healthcare institutions have been implementing PACS for over a decade, in an attempt to address the health needs of rural patients that do not have access to specialised medical care. Despite numerous deployment attempts, and the DoH’s support for PACS, the system is not operating successfully in South Africa. The purpose of the study conducted by Triegaardt (2013) was to define (a) PACS technical and operational structure suited for the South African public healthcare environment and, (b) to develop guidelines for implementation and optimisation of PACS for managing the system and the enterprise change and progressively reach the defined structure.

Further research led to establishing the (“To-Be”) PACS technical and operational structure suited for the South African public healthcare environment. Research has shown that the suited PACS technical and operational structure is a hospital-owned PACS system, free from vendor imposed limits. The system consists of two databases, one with patient information and the other with patient images. The two databases are integrated by a hospital-owned server, which accesses the separate data files by means of patient identity keys.

The requirements for the PACS implementation and optimisation guidelines for managing the system and the enterprise change to progressively reach the defined structure were developed. Different enterprise architectural frameworks, as improvement and optimisation guidelines, were considered and compared in accordance with the requirements established. A maturity model (MM) was deemed as the appropriate framework to offer guidelines for managing PACS implementation and optimisation in the public medical sector of South Africa. After establishing that the available MMs were not sufficient in process or technical system detail, a new MM was developed for the deployment and maturation of PACS.

The study was validated by means of usability study, user acceptance and goal checking, through focus group discussion and expert review. Users found the model to be a suitable deployment and optimisation guide, as well as a strategic planning tool. Verification was achieved by means of requirement analysis and consistency checking through the focus group discussions. It was found that it is needed to define a PACS technical and operational structure is suited for the South African public healthcare environment and that the guidelines for implementation and optimisation of PACS for managing the system and the enterprise needs to change to reach the defined structure functional. Implementing the use of PACS MM to reach the defined structure in South Africa will assist in improving healthcare delivery in South Africa and improving PACS system operation.

3.15 The empirical studies on electronic patient monitoring system

The study done by Ondiege, Clarke, and Mapp (2017) explored a new security framework for remote patient monitoring devices. The study highlighted that security has been an issue of contention in healthcare. In addition, the lack of familiarity and poor implementation of security in healthcare leave the patients' data vulnerable to attackers. The purpose of the study was to propose a new security framework for remote patient monitoring devices which was aimed at increasing access to quality care and decreasing costs of healthcare delivery.

The study conducted by Sandra (2013) is about the electronic health record and its contribution to healthcare information systems interoperability. The study highlighted that one of the main advantages of using computational systems in the health care activity comes from their ability to provide useful information for decision making to health professionals. The study purpose was to increment the quality and efficiency of healthcare delivery. The study further stated that in order to achieve these purposes health information systems must fulfil interoperability standards, quality, security, scalability, reliability and timeliness in data storage and processing terms. However, one of the main existing problems in this area is the fact that informatics applications do not share information, or share it at a very low level. When communication between different health information systems exists, it is mainly achieved through proprietary integration solutions.

The study conducted by Aminian and Naji (2013) was about hospital healthcare monitoring system using wireless sensor networks. The study highlighted that in a hospital health care monitoring system, it is necessary to constantly monitor the patient's physiological parameters. For example, a pregnant woman parameters such as blood pressure (BP) and heart rate of the woman and heart rate and movements of foetal to control their health condition. The study presented a monitoring system that has the capability to monitor physiological parameters from multiple patient bodies. The study proposed a system; a coordinator node has attached on patient body to collect all the signals from the wireless sensors and sends them to the base station. The attached sensors on patient's body form a wireless body sensor network (WBSN) and they are able to sense the heart rate, blood pressure and so on. This system can detect the abnormal conditions, issue an alarm to the patient and send a SMS/E-mail to the physician.

Also, the proposed system consists of several wireless relay nodes which are responsible for relaying the data sent by the coordinator node and forward them to the base station. The main advantage of this system in comparison to previous systems is to reduce the energy consumption to prolong the network lifetime, speed up and extend the communication coverage to increase the freedom for enhance patient quality of life. We have developed this system in multi-patient architecture for hospital healthcare and compared it with the other existing networks based on multi-hop relay node in terms of coverage, energy consumption and speed.

The study conducted by Vernic and Corina (2020) was about electronically health record's systems interoperability. The study was done in Romainia. The study highlighted that the electronic medical health records system has, with its various structural types and grades, has led to the elaboration of a series of standards and quality control methods meant to control its functioning. In time, the electronic health records system has evolved along with the medical data's change of structure. The study further highlighted that modern medical systems are nowadays based more and more on the easy access and real time processing of a great amount of data and medical information characterised by certain grade and type of structuring.

The study done by Anliker et al. (2020) was AMON: A wearable multiparameter medical monitoring and alert system. The study described an advanced care and alert portable telemedical monitor (AMON), a wearable medical monitoring and alert system targeting high-risk cardiac/respiratory patients. The system includes continuous collection and evaluation of multiple vital signs, intelligent multi parameter medical emergency detection, and a cellular connection to a medical center. Furthermore, the study indicated that by integrating the whole system in an unobtrusive, wrist-worn enclosure and applying aggressive low-power design techniques, continuous long–term monitoring can be performed without interfering with the patients' everyday activities and without restricting their mobility. The study described the main concepts behind the AMON system and presents details of the individual subsystems and solutions as well as the results of the medical validation.

The study conducted by Mukhopadhyay and Ewald (2012) was about a Zigbee-based wearable physiological parameters monitoring system. The study stated that the design and development of a Zigbee smart non-invasive wearable physiological parameters monitoring device has been developed. The system can be used to monitor physiological parameters, such as temperature and heart rate, of a human subject. The system consists of an electronic device, which is worn on the wrist and finger, by an-risk person. Using several sensors to measure different vital signs, the person is wirelessly monitored within his own home. An impact sensor has been used to detect falls. The device detects if a person is medically distressed and sends an alarm to a receiver unit that is connected to a computer.

This sets off an alarm, allowing help to be provided to the user. The device is battery powered for use outdoors. The device can be easily adapted to monitor athletes and infants.

The study done by Padmapriya, Goel, Sunitha, (2014) was about RFID based centralised patient monitoring system and tracking (RPMST). The study highlighted that radio frequency identification (RFID) though finds its use in many applications, still has to be accepted in a clear view. Talking in the perspective of a patient the only thing that strikes first is that lots of treatments undergone, many health records to be maintained, and after which remembering the concerned doctor’s name and other details. This becomes impossible at a certain point of time when the details have to be conveyed. To make it easier, this concept of maintaining a centralised information system and sharing has been proposed through the use of RFID technology. RFID is known for its unique ID number. Using this advantage, in the first section the monitoring of a patient is done whenever he/she arrives at the hospital. In case of any shifts from the hospital the information is still available. Every patient is provided with a unique RFID number and all the details regarding the patient and treatments are stored in a centralised database which is retrieved by the server. The second section is patient tracking where in case of any emergency in a closed environment the patient is provided with assistance in a short span of time. The patient is regularly monitored by the temperature and heartbeat sensor. The moment the value crosses the normal range a message is sent through GSM/GPS to the nearest hospital with its location and also to a relative. Assistance is provided accordingly to the patient.

The study done by Emmanuel (2009) was about an Automated System for Patient Record Management (A Case study of St Francis Hospital Nsambya). The study done by Emmanuel (2009) highlighted that patient record management systems in hospital today necessitate a competent administration when handling patients, generating reports from cashier, patient details which serves as a key factor for the flow of business transactions in St Francis Hospital Nsambya. Unfortunately, the current record management system leads to misplacement of drug details, payment details, and late release of reports and insecurity to records. The purpose of the study done by Emmanuel (2009) was aimed at computerising all the records about patients, staff and drug suppliers. In order to achieve this goal, a thorough system study and investigation was carried out and data was collected and analysed about the current system using document and data flow diagrams. The concept of report production has been computerised hence, no more delay in report generation to the hospital manager. Errors made on hand held calculators are dealt out completely. The method used to develop the system include iterative waterfall model approach, dataflow, logical and entity relationship diagram were used to design the system and finally the language used were MySql, php, HTML, Css and JavaScript.

3.16 Conclusion

This chapter was about a critical analysis of works related to this research on enabling semantic interoperability of data in heterogeneous health information systems in Namibian public hospitals. The chapter discussed the empirical study on ICT in health by explaining the critical analysis of literature around health information systems, health information system in Namibia, semantic interoperability, challenges in interoperability of data, heterogeneous distributed systems, distributed database systems, distributed systems, integration of health systems, current health silo systems in Namibia. Also, integrated health care information systems, district health information system, picture archiving and communication system and electronic patient monitoring system. The chapter explained what research has been conducted, the methodology used and the results. The next chapter covers research methodology and research theories.

CHAPTER 4: METHODOLOGY AND RESEARCH THEORIES

4.1 Introduction

This chapter discussed the research process that has been applied to investigate the research topic. Different types of research theories and methods were investigated to produce a research plan. The theories that were used were the Activity Network Theory, Grounded Theory and Design Science Research. This research was a marriage between informatics and computer science and was divided into two parts. The first part was on collecting data from the public hospitals members and interacting with the CDC and MoHSS. Therefore, the Grounded Theory and Activity Network Theory apply in the collection of data from the public hospitals, MoHSS and CDC. The Activity Network Theory identifies the role players in the public hospitals, MoHSS and CDC. The second part provided a solution to the theory and it was guided by the design of a standard-based framework for enabling semantic interoperability of disease surveillance data for Namibia through adopting health standards. Therefore, design science research (DSR) approach applies in this part.

4.2 The role of the grounded theory

The Grounded Theory was used to discover the research theory. When the research theory was formulated, design and creation research was used to test the theory. The following sections take the reader through the research design that has been followed, and a discussion as to why specific research methods have been chosen over the others, how data collection techniques, sampling methods and the interpretation of data have been carried out.

4.3 The role of design science research

The Design Science Research has enabled this study to get a better grasp of the research problem. The re-evaluation of the research problem improves the quality of the design process. In addition, Design Science Research enabled this study to build and evaluate, a loop typically iterated a number of times before the final design artefact is generated. In other words, design science research focuses on the so-called field-test and grounded technological rule that aims at solving complex and relevant field problems (March & Storey, 2008). The Design Science Research helped this study to achieve the following seven guidelines during the research design process that include:

- designing as an artefact that enabled the study to produce a viable artefact in the form of a construct,
- a model,
- a method or an instantiation,
- another guideline is research problem relevance that helped this study to develop technology-based solutions to important and relevant health dissemination research problems,
- design evaluation as a guideline helped this study to consider the utility, quality and efficacy of a design artefact that is rigorously demonstrated via well-executed evaluation methods,
- The other design science research guideline is research contributions that enabled this study to provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/ or
- Design methodologies of this study.

- To understand how healthcare information is currently exchanged/shared between the service provider and the communities in Namibia
- To examine how information relating to healthcare can be distributed and accessed through mobile technologies
- To design and develop a mobile application for health information sharing

The chapter was structured as follows: the first section discussed the research design used for this study, namely the research paradigm, research approach, data collection and data analysis. Ethical considerations were applied for and approved as data collection involved human beings. Data was collected through semi-structured interviews and questionnaires which were analysed to reach a certain conclusion for a given problem. Details of research methods used to select a sample and collection of data are clarified in detail below.

4.4 Research design

The research design refers to the overall strategy that the research study chose to integrate the different components of the study in a coherent and logical way, thereby, ensuring that the research study has effectively addressed the research problem. It constitutes the blueprint for the collection, measurement, and analysis of data (De Vaus, 2001).

In addition, the research design is the overall plan for connecting the conceptual research problems to the pertinent empirical research (Van Wyk, 2015). In other words, the research design articulates what data is required, what methods are going to be used to collect and analyse this data, and how all of this is going to answer the study research questions, that is, both data and methods, and the way in which these will be configured in the research project. The research design that is used in this research study started with an investigation into how disease surveillance data can be exchanged and communicated through adopting health standards.

The aim of the first phase of the research design was to perform a literature review on a standard-based framework for enabling semantic interoperability of disease surveillance data for Namibia through adopting health standards which fed into phase 2. Covering the issues surrounding health information systems helped understand the background to the challenge. After conducting the literature review, the next phases (2-4) were on planning how the research will be performed by elaborating on the research methodology approach and this is discussed in more detail in the next sections.

4.5 Research paradigms/ philosophy

The interpretivism paradigm was used to structure the research and to show how all the major parts of the research project will work together in trying to address the central research questions. The research philosophy for this study was based on interpretivism, which is described as a philosophy that advocates the necessity to understand differences between humans in their role as social actors in their natural environments (Saunders & Lewis, 2012). According to Willis (2007), interpretivism usually seeks to understand a particular context, and the core belief of the interpretive paradigm is that reality is socially constructed. Research paradigms can be used in carrying out scientific investigations on a specific topic which stresses on a subjectivist approach to studying social phenomena. It attaches importance to a range of research techniques focusing on qualitative analysis, e.g. personal interviews, participant observations, accounts of individuals and personal constructs (Nirod, 2016).

The research paradigm used in the study was a qualitative approach. A qualitative approach was selected primarily for it enabled the study to gather data from the staff of Centre for Disease Control and Prevention (CDC), public hospitals and the MoHSS. A qualitative approach was selected over other methods since it allowed the study to engage with the participants fully in order to acquire disease surveillance information adopting health standards and avoid leaving gaps during the collection of data. The interpretive technique was used to analyse data collected from the CDC, public hospitals and the MoHSS. A quantitative approach is one in which the investigator primarily uses post-positivist claims for developing knowledge (i.e. cause and effect thinking, reduction to specific variables and hypotheses and questions, use of measurement and observation, and the test of theories) (Nirod, 2016). A qualitative approach is the study of things in their natural settings, in an attempt to interpret, and make sense of the phenomenon in terms of the meanings people bring to them.

The qualitative research method was selected as a strategy, meaning that, qualitative data were collected from CDC staff, public hospitals and the MoHSS. This is mainly for the reason that qualitative types of data are an expressive opinion involving actors. This type of data would help to understand the interaction which takes place between human-to-human, human-to-technology, and technology-to-technology, in the delivery of healthcare services. The qualitative research method was selected primarily since it allows research to gather data of subjective views and opinions from individuals and groups. The secondary methods were the conceptual design, literature survey and prototype.

Conceptual design is the very first phase of design, in which drawings or solid models are the dominant tools and products (Bekhradi et al., 2016). Bekhradi et al. (2016) further describe a conceptual design phase as a description of the proposed system in terms of a set of integrated ideas and concepts about what it should do, behave, and look like, that will be understandable by the users in the manner intended.

A literature survey represents a study of previously existing material on the topic of the report (Rowe & Larsen, 2017).

This includes:

I. Existing theories about the topic which are accepted
universally II. Books written on the topic, both generic and specific III.
Research done in the field usually in the order of oldest to latest
IV. Challenges being faced and ongoing work, if available

A prototype is an early sample, model, or release of a product built to test a concept or process or to act as a thing to be replicated or learned from. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming (Blackwell & Manar, 2015). A prototype is designed to test and try a new design to enhance precision by system analysts and users. Blackwell and Manar (2015) argue that prototyping serves to provide specifications for a real, working system rather than a theoretical one.

4.6 Ethical considerations

On ethical considerations, the research had to obtain permission from DUT research ethics committee, from the CDC, public hospitals and from the MoHSS in order to investigate the research topic. This led to the gathering of relevant health related disease surveillance data that helped this study to ensure that health disease surveillance information was accessible and can be exchanged from one public hospital to the other public hospitals. As a result, this enables health professionals to receive and exchange disease surveillance information anytime and anywhere without physically visiting the CDC, hospitals, clinics, health centres and health non-profit organisations that disseminate disease surveillance information from one public hospitals to another public hospital through adopting health standards.

4.7 Research ethics

According to Akaranga and Makau (2016), research ethics are moral codes that should be abided by the researcher when conducting a research. In addition, this means that it governs the researcher in order to be able to distinguish between right and wrong when conducting a research. The study has ensured that no person's rights were violated in any manner during the research study. Explanations about the nature of the study were highlighted to the participants' prior participation. Anonymity and confidentiality were treated in obsolete confidence during the research study process.

As stated in the research objectives and indicated in the research methods section, the research was carried out at the CDC, Public hospitals and with the MoHSS. The study abided by the ethics code of the Centre for Disease Control and Prevention (CDC), public hospitals and human research. Initially permission was obtained from DUT research ethics committee for compliance and to undertake the research. The research ethics of the Durban University of Technology (DUT), under which this study was conducted was strictly adhered to throughout the course of this study. The study abided by the ethics code of CDC, public hospitals and ensured that no personal information about CDC staff, public hospitals and MoHss was stored except information on gender and age. Any information collected from this project would remain confidential and would be used for the PhD's thesis and academic publications. In the documentation of the work, a pseudonym was used (instead of the given names) for identification purposes. Information that would make it possible to identify a participant would never be included in any part of the report, or disclosed outside the project, unless explicit permission has been given. The data collected was used to produce this PHD's thesis and possibly a proposal for a standards-based framework for enabling semantic interoperability of disease surveillance data for Namibia through adopting health standards.

4.8 Processes followed to obtain permission to interview CDC staff members, public hospitals members and MoHSS

Before the field survey and data collection was done, consultation was made with the MoHSS which is the custodian that approves any research conducted at the ministry, public hospitals or CDC. The department of research at the ministry requested the study to provide the following documents: the research proposal, the CV of the researcher, ethical consent letter from the Durban University of Technology (DUT), and proof that the researcher had completed a registration research form from the ministry before being granted permission to conduct a research study at the ministry. These documents were submitted to the office of the permanent secretary who has the mandate to approve the research study. The approval of this research study took 3 months and the researcher was telephonically informed by the secretary to the permanent secretary to go and carry out the intended research study.

4.9 Processes followed to obtain research clearance from DUT

DUT requires all post graduate students to identify the topic they would want to research on. The students are given 6-9 months, 6 months for full time students and 9 months for part time students to write a research proposal with their supervisor. It is only until the supervisor approves the research proposal and then three faculty members evaluate the proposal before the proposal is send to high degree committee for approval. The student has to present the proposal at the faculty level and gets input from different faculty members of the university. Finally, students have to submit their proposal to the post graduate committee that finally gives the student the go ahead to continue writing the thesis.

The theories adopted in this research were the Activity Network Theory, the Grounded Theory and the Design Research Theory.

4.10 Design and creation research

Design science research is a set of analytical techniques and perspectives for performing research in Information Systems (IS) (Kuechler & Petter, 2012). Kuechler & Petter (2012), further state that Design Science Research involves the design of novel or innovative artifacts and the analysis of the use and/or performance of such artifacts to improve and understand the behaviour of aspects of information systems. In Design Science Research, as opposed to Explanatory Science Research, academic research objectives are of a more pragmatic nature. Research in these disciplines can be seen as a quest for understanding and improving human performance.

I. Phases of design and creation research (Hanacek, n.d.):

The table below describes different research phases and definitions:

Research Phase	Definition
The Conceptual Phase	Formulating the clinical problem, reviewing the literature, and determining the research purpose
The Design and Planning Phase	Selecting a research design, developing study procedures, determining the sampling and data collection plan
The Empirical Phase	Collecting data and preparing data for analysis
The Analytic Phase	Analysing the data and interpreting the results
The Dissemination Phase	Communicating results to appropriate audience

Table 1: Phases of design and creation research

The design and creation research was applied in this thesis as an initial research design that determined the research purpose, the sampling and data collection plan, collecting data and preparing data for analysis. The design and creation research was applied in this thesis through the development of the mobile application that needs to be fully understood by the actors involved in the usage and functionality of the application. The actors involved need to acquaint themselves with the technology oriented platform initiated for them to be able to execute their activities, in this case nurses, health assistants and doctors.

4.11 Grounded theory

The Grounded Theory is a systematic set of procedures to develop an inductively derived theory from the data (Moghaddam, 2006). Important tools of Grounded Theory are theoretical sampling, coding, and constant comparison. Theoretical sampling is "the process of data collection for generating theory whereby the analyst jointly collects, codes, and analyses the data and decides what data to collect next and where to find them, in order to develop his theory as it merges" (Corbin & Strauss, 2015).

In constant comparison one compares data (for instance, an interview) to other data (for instance, another interview). After a theory has emerged from this process new data is compared with the theory. If there is a bad fit between data (interviews), or between the data and your theory, then the categories and theories have to be modified until your categories and your theory fit the data. In constant comparison, discrepant and disconfirming cases play an important role in rendering categories and Grounded Theory.

The Grounded Theory was used in order to guide on the number of participants engaged in the study, sampling, coding and constant comparison. The Grounded Theory was applicable simply for the reason that it guided the study to do a comparison on the gathering of semi-structured data obtained specifically from the CDC and on the other hand the data gathered from the MoHSS and Public hospitals. Grounded theory has guided the study in constant comparison, for instance between the data and the study theory, in order to categorise theories and to check whether the theory fits the data. In addition, grounded theory has enabled the study to analyse the data and decide what data to collect next and where to find them, in order to develop the theory as it emerges.

4.12 Selecting participants

The research was in two phases. The first phase was the collection of data on the status of semantic interoperability of HIS in the Namibian healthcare sector. The case study setting was based on public hospitals from eight regions in Namibia with two (2) public hospitals per region which was purposely sampled. The study population comprised of system analyst, programmers, chief system administrators, system administrators, disease surveillance office, chief disease surveillance office, nurses, doctors, therapists, health assistants, health public officers, health administrators, regional health coordinators and regional assistant coordinators. Stratified purposive sampling of the study participants was done. This first phase followed an interpretive approach and supported a mixed methods approach encompassing both qualitative and quantitative data analyses. The Grounded

Theory was the underlying theory of this research. The second phase was the design and development of the semantic interoperability framework. The Design Science Research approach guided the development of the framework and prototype. Expert reviews were sought to review and validate the framework and prototype that was developed.

4.13 Research sample

The study population comprised of, system analyst, programmers, chief system administrators, health information system administrators, disease surveillance office, chief disease surveillance office, nurses, doctors, therapists, health assistants, health public officers, health administrators, regional health coordinators and regional assistant coordinators from hospitals in eight regions. Purposive sampling of hospitals and participants within 8 regions were conducted at 2 hospitals per region. A sample of hospitals per region were used and this included the following participants per selected public hospitals per region:

Table 2: Population target research sample

Name of selected participants	**Numbers of participants in each region**	**Number of public hospitals per region selected**
Nurses	5	2
Doctors	6	1
Therapists	3	2
Health assistants	4	1
Health public officers	4	1
Health administrators	3	2
Regional health coordinators	2	1
Regional health assistant coordinators	4	1
System Analyst	4	1
Programmers	4	2
Chief system Administrator	2	1

Health information System administrators	4	2
Disease surveillance office	4	2
Chief disease surveillance office	2	2
	51	**21**

Semi-structured interviews were formulated with the purpose to acquire disease surveillance data from 21 public hospitals per region which included 51 participants in each region.

The semi-structured interview technique conducted allowed flexibility during data collection. This included instant probing of participants for answers that were obtained as this was done face to face. The semi-structured interview used allowed the flexibility to rephrase and restructure the questions during the interviews.

4.14 Data collection

Questionnaires and semi-structured interviews were used to collect qualitative and quantitative data from system analyst, programmers, chief system administrators, health information system administrators, disease surveillance office, chief disease surveillance office, nurses, doctors, therapists, health assistants, health public officers, health administrators, regional health coordinators and regional assistant coordinators. The questionnaires were derived from the critical analysis of literature.

Each group was interviewed using the same semi-structured interview. The sample size was 51 health personnel at the Centre for Disease Control and Prevention, MoHss. Each interview took an average of 60 minutes and when data was collected, a tablet was used to do data transcribing. At the central hospital level during data collection, interviews were conducted where by nurses were interviewed in one group, followed by a group of doctors, a group of therapists, a group of health assistants, a group of health public officers, a group of health administrators, a group of health coordinators, a group of regional health assistant coordinators, a group of system analyst, a group of programmers, a group of chief system administrator, a group of health information administrators, a group of disease surveillance officer and a group of chief disease surveillance officer. The purpose of the semi-structured interviews was to get a better understanding on how disease surveillance data is communicated and exchanged among public hospitals and CDC in Namibia. In the second group, the study also interviewed public hospitals. In total, 800 questionnaires were distributed and completed in eight regions in public hospitals.

4.15 Interviews and data gathering

An interview is defined as a conversation where questions are asked and answers are given. In other words, it refers to a one-on-one conversation with one person acting in the role of the interviewer and the other in the role of the interviewee. In addition, questions are asked, and answers are given, with participants taking turns to talk. However, interviews usually involve a transfer of information from interviewee to interviewer, which is usually the primary purpose of the interview, although information transfers happen in both directions simultaneously. In this case nurses, doctors and health assistants were engaged in an interview in order to provide general diseases information on how information reaches the communities in Namibia. Data gathering is a process of collecting data from all the participants that are engaged in the study with the purpose to answer the research questions and achieve the research objective in order to draw a conclusion on the findings.

4.16 Research instruments

To come up with the questions a critical analysis of related literature was conducted. This critical analysis is what identified gaps in the literature on current semantic interoperability of data in heterogeneous health information systems. It is from these gaps that questions were identified.

The study interviewed the member of CDC, MoHSS, Central Windhoek Hospital and Katutura State hospital. The study used questionnaires with a sample of selected public hospitals members who were working for public hospitals to complete a questionnaire and also to give their opinions on how they exchange disease surveillance data with other public hospitals, CDC and MoHSS. However, before the survey, interview questionnaires were handed over to the participants who were engaged in the study. Seven participants were selected for the purpose of testing whether the questionnaires set up can be understood by the participants but eventually the questionnaires provided the answers to the study research questions.

The survey interview public hospitals questionnaires selected enabled the study to gather concrete data through insightful views and opinions from both participants; the public hospitals who were engaged in the study. The survey was used in the study to gather data from the public hospitals using questionnaires. The public hospitals members completed the questionnaires and returned the questionnaires.

The aim of the public hospitals questionnaire was to find out how the public hospitals communicate and exchange disease surveillance data among public hospitals in Namibia through adopting health standards.

During the survey, public hospitals questionnaires conducted various sorts of questions were asked in order to get an overview or background as on how the public hospitals communicate and exchange surveillance data between public hospitals, CDC and MoHSS. The questionnaires were designed in a format that enabled participants to tick or cross their answers based on their gender as well as space provide to feel in their answers. Some of the questions were as follows: how do you exchange and communicate disease surveillance data through adopting health standards other public hospitals, CDC, MoHSS and what technology platform do you make use of. In addition, a public hospitals survey interview was conducted through the use of questionnaires distributed to the 8 regions in Namibia using public hospitals. The study tested the questions in the questionnaires before distributing them to the public hospitals of the 8 regions in Namibia. A total of 800 questionnaires were distributed to the public hospitals of 8 regions in Namibia, to get the views of individuals on how disease surveillance data is exchanged or communicated among CDC, MoHSS and public hospital members.

4.17 Semi-structured interviews

The semi-structured interviews were conducted at the Center for Disease Control, Windhoek Central hospital, Katutura State hospital and MoHSS to gather disease surveillance data. The office of the medical superintendent was approached in order to grant the study a permission to engage IT personnel due to the sensitivity of healthcare facilities. The study engaged system analysts, programmers, chief system administrators, health information system administrators, disease surveillance office, chief disease surveillance office, nurses, doctors, therapists, health assistants, health public officers, health administrators, regional health coordinators and regional assistant coordinators. Each semi-interview conducted at the hospital lasted for 60 minutes.

4.18 Questionnaires directed to ICT staff through interviews

Number of ICT personnel was engaged to get an understanding on how semantic interoperability of disease surveillance data are exchanged and communicated among the ICT staffs in Namibian public hospitals, MOHSS and CDC. The findings of the research were as follows.

4.19 Interviews with technicians

According to the two IT technicians at the local hospital in Windhoek, there is management system for advanced staff. In addition, they further stated that they do not have a system or framework that aggregates data from remote health systems for management staff to view and analyse information and also, they do not have a system that exchanges data automatically. The system or framework developed in this study would aggregate data from remote health systems for management staff to view and analyse information for hospitals' decision making. The two technicians further stated that, they do not have a system or framework for semantic interoperability of data in Namibian public hospitals. Currently, what system administrators do is login remotely and access a file in another computer on the same network which does not allow silo systems data to be accessed, communicate, and exchange health data and information from other silo systems hosted in other Namibian public hospitals. The system proposed would exchange data automatically from heterogeneous health information silo systems in Namibian public hospitals. The systems exchange data automatically so there should be no staff entering data manually. Furthermore, the technicians indicated that public hospitals have standalone silo systems, and there is no communication between silo systems at the moment. At the present moment, users go physically to the silo systems wherever they are installed in public hospitals. All users are role-based, which means every user on a silo system is responsible for the silo they use. There is no method used to access health data from another silo system at the moment; there is no method of extracting health data from another silo system operating in the same environment; and there is no protocol or layer used to govern silo systems in public hospitals at the moment. Therefore, the study proposed to develop a model to enable semantic interoperability of data in heterogeneous health information systems in Namibian public hospitals for management committees that involves all the heads of departments in all public hospitals in Namibia.

Table 3: Technicians interviews

Technician interviews				
Technician	1	MoHSS have stand alone systems	No exchanging of data in the current system	Technician move from one hospital if they need disease surveillance data
Technician	1	MoHSS have silo systems	No exchanging of data in the current system	No exchange of disease surveillance data from one hospital to the other
Total	**2**			

Table 3 above symbolises the responses from the two technicians interviewed in a local hospital in Windhoek who clearly stated that at the present moment hospitals in Namibia had standalone silo systems that work in isolation and they do not communicate and exchange health related information to one another. The two technicians highlighted that this is a main challenge in the Namibian health sector simply because if a technician requires data from remote silo systems in another hospital, they are required to go physically to that specific hospitals in order to acquire health related data. As a result, the study developed a protocol for the exchange of data from remote systems and aggregation of that data into meaningful information. In today's world, protocols are known as the most essential components in semantic interoperability of multiple information systems for the fact that they act as agreement on how something has to be done. In addition, a protocol in general is the special set of rules that end points in a telecommunication connection use when they communicate.

Moreover, protocol specify interactions between the communication entities in this case the protocol was applied to govern heterogeneous systems in Namibian public hospitals for data semantic interoperability of DHIS-2 and these other health information silo systems so that they can exchange health data and information. The study has discovered a new interlink protocol as a layer between health remote systems to govern the communication, exchange of data and information among heterogeneous health silo systems in Namibian public hospitals.

4.20 Questionnaires distributed to the 8 regions in Namibia

Questionnaires were distributed equally to the 8 regions in Namibia to give an understanding on how disease surveillance data is communicated and exchanged among CDC, MoHSS and public hospitals in Namibia. A total of 800 questionnaires were divided among 8 regions in Namibia to be completed by public hospitals members.

- **ERONGO REGION**

Hundred (100) questionnaires were distributed in a public hospital in Erongo region and only 56 questionnaires were completed and returned to the researcher.

- **KARAS REGION**

Hundred (100) questionnaires were distributed in a public hospital in Karas region and only 35 questionnaires were completed and returned to the researcher.

- **KHOMAS REGION**

Hundred (100) questionnaires were distributed in a public hospital in Khomas region and only 50 questionnaires were completed and returned to the researcher.

- **KUNENE REGION**

Hundred (100) questionnaires were distributed in a public hospital in Kunene region and only 39 questionnaires were completed and returned to the researcher.

- **OHANGWENA REGION**

Hundred (100) questionnaires were distributed in a public hospital in Ohangwena region and only 37 questionnaires were completed and returned to the researcher.

- **OMUSATI REGION**

Hundred (100) questionnaires were distributed in a public hospital in Omusati region and only 27 questionnaires were completed and returned to the researcher.

- **OTJOZONDJUPA REGION**

Hundred (100) questionnaires were distributed in a public hospital in Otjozondjupa region and only 29 questionnaires were completed and returned to the researcher.

- **ZAMBEZI REGION**

Hundred (100) questionnaires were distributed in a public hospital in Zambezi region and only 52 questionnaires were completed and returned to the researcher.

4.21 Document sampling

Document sampling is when you choose documents for analysis from the long list of documents collected for the issue histories (doMbos, 2012). For the purpose of comparability, documents selected had to be similar in topic and type. The review of a variety of existing sources (e.g., documents, reports data files, and other written artefacts) is done with the intention of collecting independently verifiable data and information.

4.22 Data analysis

Data analysis entails examining, categorising and summarising information in order to establish meaning and maintain evidence (Schoenbach, 2014). Schoenbach (2014) further states that the analysis process is managed by organising, summarising and interpreting data. The interpretive technique was employed to analyse qualitative data. This approach was selected since it is a research standardised approach that comprises of steps on how the data collected should be analysed. Step one is data reduction which means an analytic process through which the qualitative data that the researcher gathered are reduced, rearranged, and integrated to form theory. Step two is data display which involves the researchers taking reduced data and displaying them in an organised, condensed manner. Step three is drawing conclusions - at this point the research questions are answered by determining what identified themes stand for, by thinking about explanations for observed patterns and relationships, or by making contrasts and comparisons. An interpretive technique was used to analyse data from the CDC, NIP and MoHSS. The information from the CDC, NIP and MoHSS that was analysed was on current information technologies to exchange disease surveillance health information, critical success factors to deployment of technologies, challenges with the manual among public hospitals members.

A software tool (i.e. SPSS) was used to analyse quantitative data from the public hospitals to obtain the percentages.

4.23 Research methodology as a concept

A research methodology can be defined as the methods and techniques that are employed in the study to collect data, the type of data that is collected, and how the data is analysed (Iyamu, 2013). In this case the research question was**: "**How can the comprehensive standard-based framework for disease surveillance data semantic interoperability of DHIS-2 and these other health information silo systems for them to exchange disease surveillance data and information be achieved using health standards?**"**

4.24 Case study approach

The study adopted a case study as the main approach. According to Babbie and Mouton (2001, pp.2001-246), a case study is "an intensive/ in-depth investigation of a single unit." Since the study was dealing with different healthcare facilities, the primary research method was the case study. The only stakeholder in accessing disease surveillance data is MoHSS under the department of epidemiology. The other stakeholders are the recipients who are the united nation headquarter, CDC and public hospitals. So, the two case studies are: one, in which the epidemiology department under MoHSS disseminates disease surveillance data report to the united nation headquarter in a spreadsheet format. The case study was selected in this study since it focuses on collecting information about a specific object, event or activity such as a particular business unit or organisation.

However, the study selected a case study mainly for the idea behind a case study that it clearly gives a picture of a problem. One must examine the real-life situation from various angles and perspectives. The case study was used since it is a research strategy that involves an empirical investigation of a particular contemporary phenomenon within its real-life context during data collection. A multiple case study is defined as studying and comparing cases in their totality (holistic), and studying various units within identifiable cases (embedded). A multiple case study enables the researcher to explore differences within and between cases. The goal is to replicate findings across cases. Since comparisons will be drawn, it is imperative that the cases are chosen carefully so that the researcher can predict similar results across cases, or predict contrasting results based on a theory (Sekaran, 2013). A multiple or collective case study will allow the researcher to analyse phenomenon within each setting and across settings. While a holistic case study with embedded units only allows the researcher to understand one unique/extreme/critical case, in a multiple case study, we are examining several cases to understand the similarities and differences between the cases.

Advantages of multiple case studies are:

- Evidence from more case studies is more compelling
- It is imperative that the cases are chosen carefully so that the researcher can predict similar results across cases, or predict contrasting results based on a theory.

Disadvantages of multiple case studies

- Yet, a multiple case-study design by definition does not involve critical, unusual or revelatory cases.
- This type of a design has its advantages and disadvantages. Overall, the evidence created from this type of study is considered robust and reliable, but it can also be extremely time consuming and expensive to conduct.

Continuing with the same example, if you wanted to study women in various health care institutions across the country, then a multiple or collective case study would be indicated.

4.25 Laboratory experimentation

The prototype and interlink of the system is developed in a laboratory setup. Different stages of the life development life cycle were employed during the prototype development to ensure that the prototype suites the end user.

4.26 Conclusion

This chapter explained the methods, techniques and theories that were employed in the study, to collect data, the type of data collected, and how the data was analysed. The selection of the methods and techniques were influenced by the goal of the study, which was to design and develop a comprehensive standards-based framework for data semantic interoperability of DHIS-2 and other health information silo systems so that they can exchange disease surveillance health data and information through adopting health standards. The next chapter covers data analysis and findings.

CHAPTER 5: DATA ANALYSIS AND FINDINGS

5.1 Introduction

This chapter covers data presentation, analysis and interpretation thereafter. Data were gathered through survey questionnaires. With the help of Microsoft Excel and IBM SPSS Statistics version 22, the chapter presents the outcome from 325 respondents in the form of, graphs and pies charts for easy comparison and interpretation thereafter. A mixed approach was employed in this study to get an understanding of the current status of semantic interoperability in the Namibian health domain. The study conducted a survey from public hospitals in 8 regions in which 100 questionnaires were distributed to each region.

5.2 Response Rate

A total of 800 questionnaires were distributed with one public hospital selected in each of the 8 regions selected. A total of 325 questionnaires were completed with Erongo region having the highest number with 56 questionnaires completed, and Omusati with the lowest number of 27 questionnaires completed as show from fig 5.1. The other regions were as follows; Zambezi region which had recoded 52 responses, Karas region had 35; Khomas region with 50; Kunene region had 39; Ohangwena had 37 and Otjozondjupa region had 29.

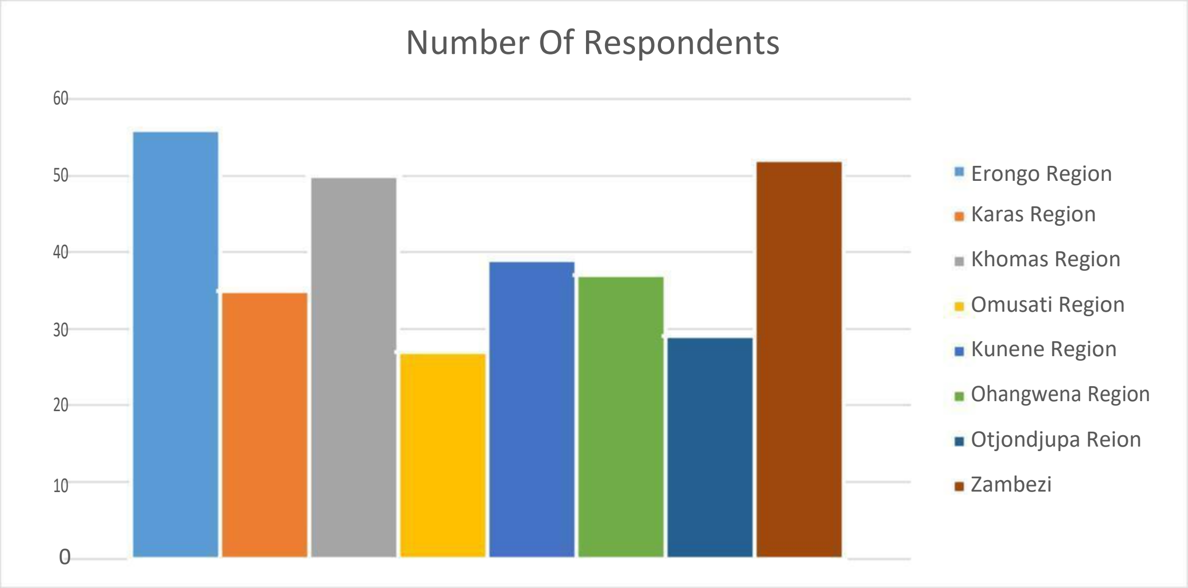


Fig 5.1: Number of Respondents

5.3 Data Preparation

Once the survey was closed, the data was reviewed in Survey Monkey. All response data was exported to Microsoft Excel in both coded numerical format and actual answer test formats. Both formats were needed at the later stage when preparing the data for import into SPSS which did require an element of work. Preparing the data for import into SPSS from the Excel sheet was a time-consuming but worthwhile exercise as it allowed for a low-level review of the data. Each question was optional, thus when a record was empty it indicated that the respondent decided not to answer the specific question. Missing data was coded as the numerical value 0 to indicate these situations.

Once the Excel data was imported into SPSS, further preparatory work needed to be carried out. Each variable needed to have a label, an associated value and a measurement variable defined for it. For measurement SPSS distinguishes three levels:

a) Nominal: The answers given have no logical order. A typical example is the gender.
b) Ordinal: With an ordinal scale there is a logical order, but no numbers are asked for. A typical example is a scale like: bad - neutral - good.
c) Scale: Chosen if a number is being requested. A typical example would age

Once the measurement variables have been defined the data is ready for further analysis.

5.4 Descriptive Statistics: Public hospitals for 8 regions interview findings

In this section interview findings were analysed according to each of the 8 regions.

5.4.1 Erongo Region

This section looks at statistics according to gender and age.

5.4.1.1.Gender

Of the 56 respondents from Erongo Region understudy, 57% (n=32) were male respondents, while 43% (n=24) were female respondents as shown in fig 5.2 below.

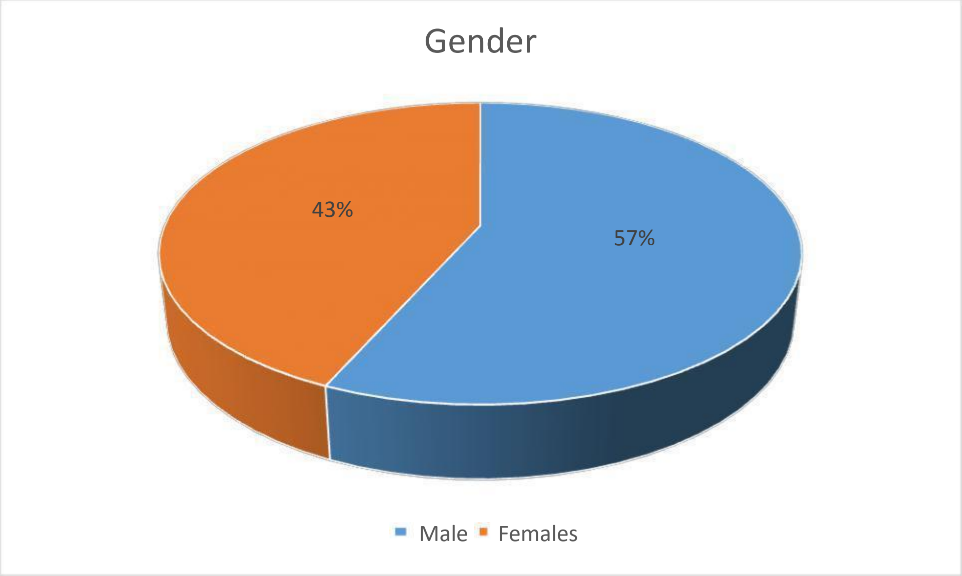


Fig 5.2 Gender

5.4.1. 2 Age group

Results in fig 5.3 shows that more than half (52%) of the participants in the age group 26-35 year. The observation was then followed by 27% of the participants whom were in the age group 18-25, while the least observation was obtained from those respondents who were above 45 as they were only constituting 14% of the sample in the region.

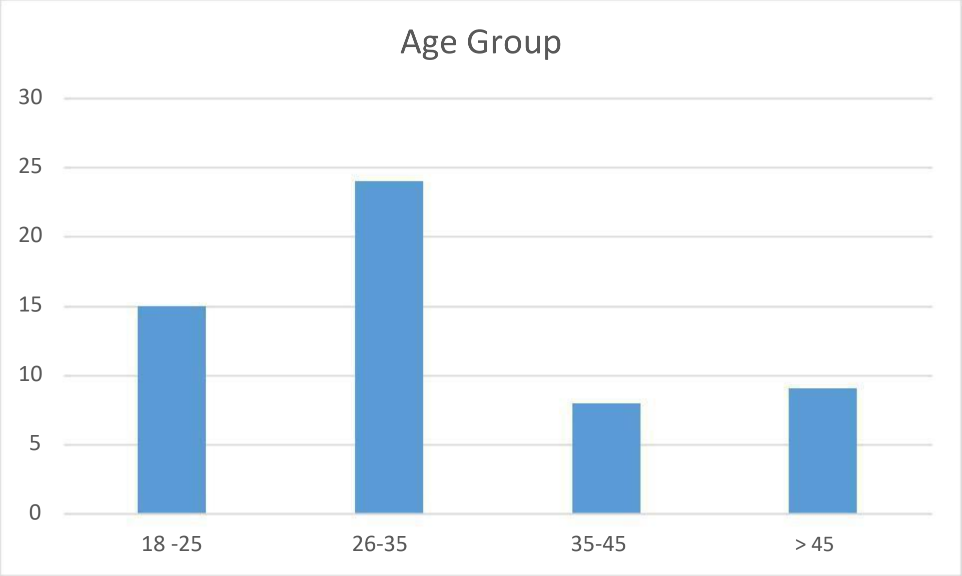


Fig 5.3: Age Group

5.4.1.3 Ways used to exchange disease surveillance data with other hospitals

Fig 5.4 below indicates that 34 participants were using health programs to exchange disease surveillance data with other hospitals. The observation was then followed by that one of 24 respondents who had indicated that the exchange disease surveillance data with other hospitals through other staff members. However, the least respond was observed from only 2 respondents who were not sure of the ways in which they exchange disease surveillance data with others.

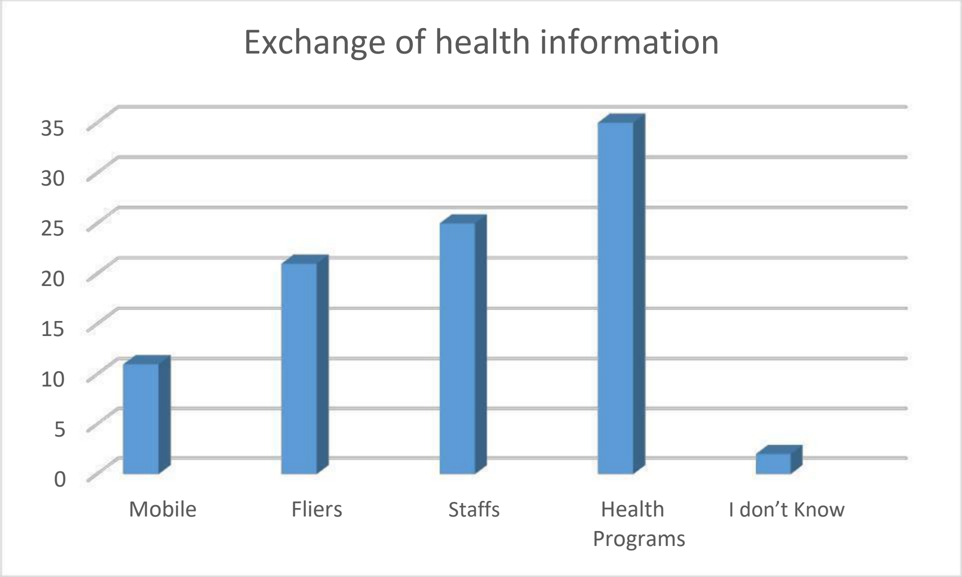


Fig 5.4 Exchanging of health information

5.4.1.4 Accessing disease surveillance data from another public hospitals in Namibia

As shown in fig 5.5, majority (82%) of the respondents had indicated that they access disease surveillance data from another public hospitals in Namibia through visiting hospitals or clinics. The observation that then followed by 32% of the respondents who had indicated that they access through fliers, while the least responds was obtained from 4% of the respondents who indicated mobile phones.

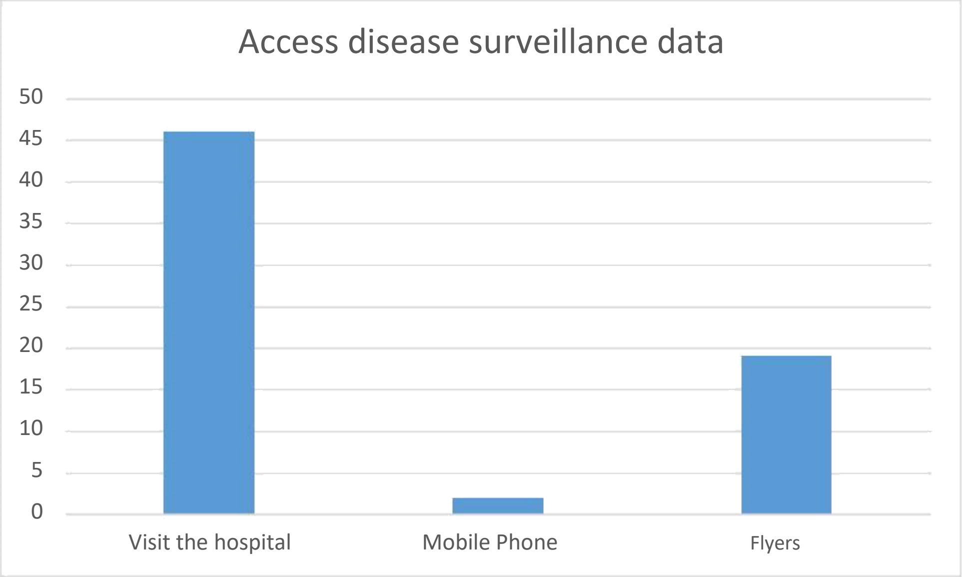


Fig 5.5: Accessing disease surveillance data

5.4.1.5. Type of disease surveillance data exchanged with other public hospitals

When asked about type of disease surveillance data exchange with other public hospitals, 64% of the respondents had indicated that they exchange campaign related data with other public hospitals, while 36% and indicated that exchange their health record data as shown in fig 5.6 below.

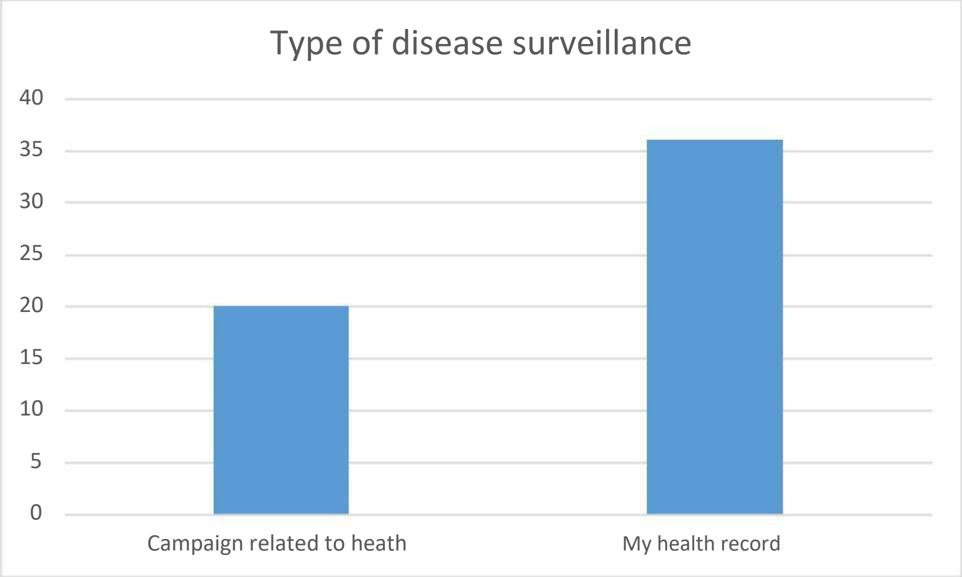


Fig 5.6 Types of disease surveillance data exchanged

5.4.1.6 Preferred ways of receiving disease surveillance data

Fig 5.7 present preferred ways of receiving disease surveillance data by the respondents. The figure shows that 50% of the respondents prefers visiting the hospitals, followed by 46% of the respondents who preferred mobile phones while the least response was observed from 18% prefers to receive through fliers.

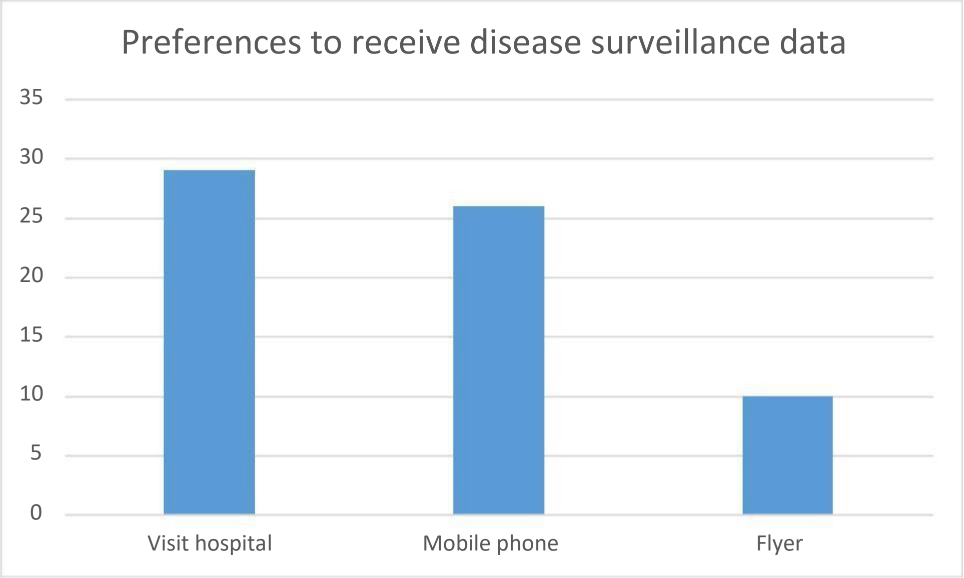


Fig 5.7: Preferred ways of receiving disease surveillance data

5.4.1.7 Types of disease surveillance data wanted to be received from other public hospitals

Fig 5.8 shows that 73% of the respondents want to receive HIV/ AIDS information from other public hospitals. The observation was then followed by 71% who indicated that they want to receive cancer information. However, the least observation was obtained from 27% of the respondents who indicated that want to receive Ebola information.

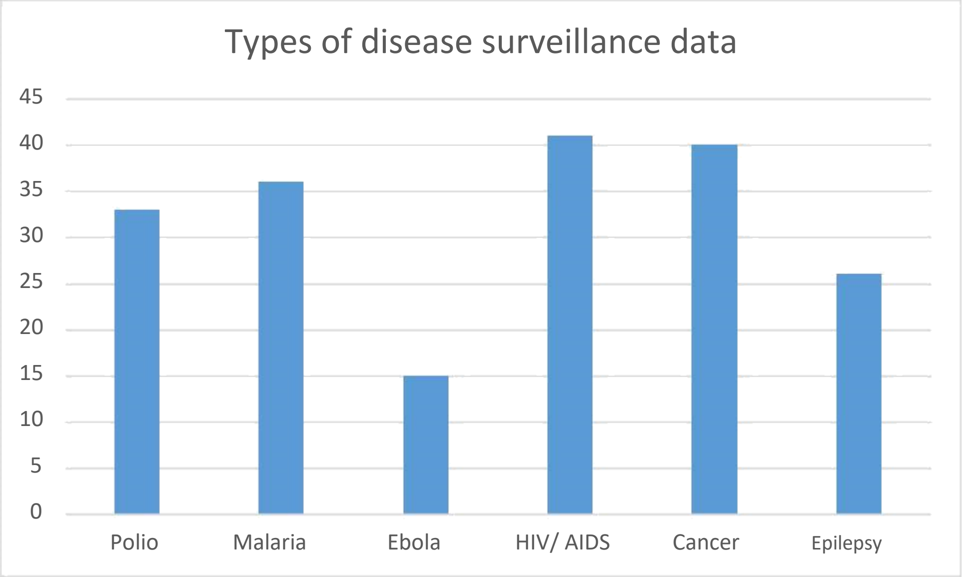


Fig 5.8: Types of disease surveillance

5.4.1.8. Duration to receive the information from other public hospitals

Fig 5.9 portrays a graphical presentation of the time frame taken to accessing disease surveillance data. The highest response was obtained from 64% of the respondents who indicated that it took 1 to 5 weeks for them to receive information from other public hospitals. The observation was then followed by 32% of the who indicated that it took them 5 to 10 weeks. However, the least observation was obtained from 16% of the respondents, who had indicated that it only takes them a day to access the information from other public hospitals

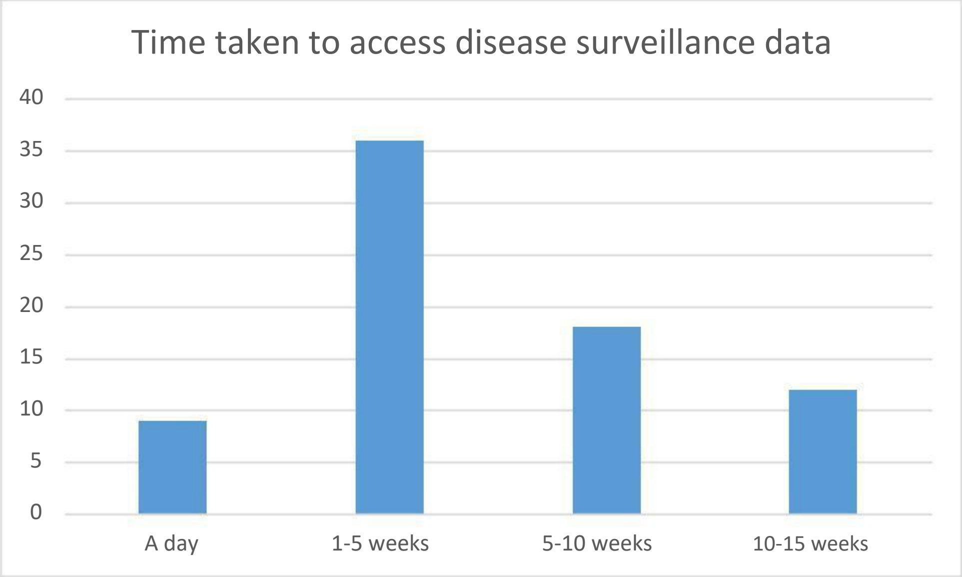


Fig 5.9 Duration to access disease surveillance data

5.4.2 Karas Region

This section looks at statistics according to gender and age.

54.2. 1.Gender

Of the 35 respondents from Karas Region understudy, 51% (n=18) were male respondents, while 49% (n=17) were female respondents as shown in fig 5.10 below.

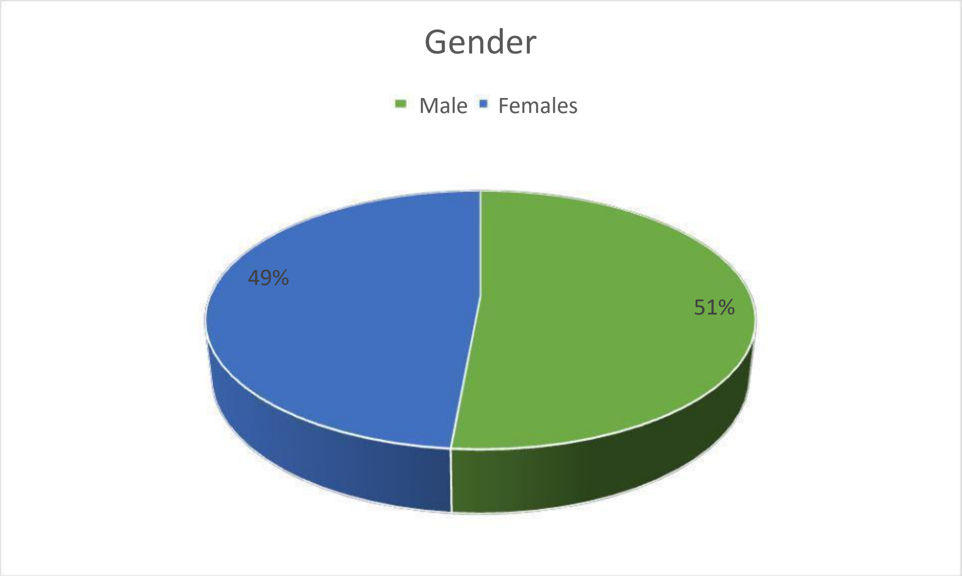


Fig 5.10 Gender

5.4.2.2 Age group

Results in fig 5.11 shows that 44% of the participants in the age group 26-35 year. The observation was then followed by 31% of the participants whom were in the age group 18-25 year, while the least observation was obtained from those respondents who were above 45 as they were only constituting 5% of the sample in the region.

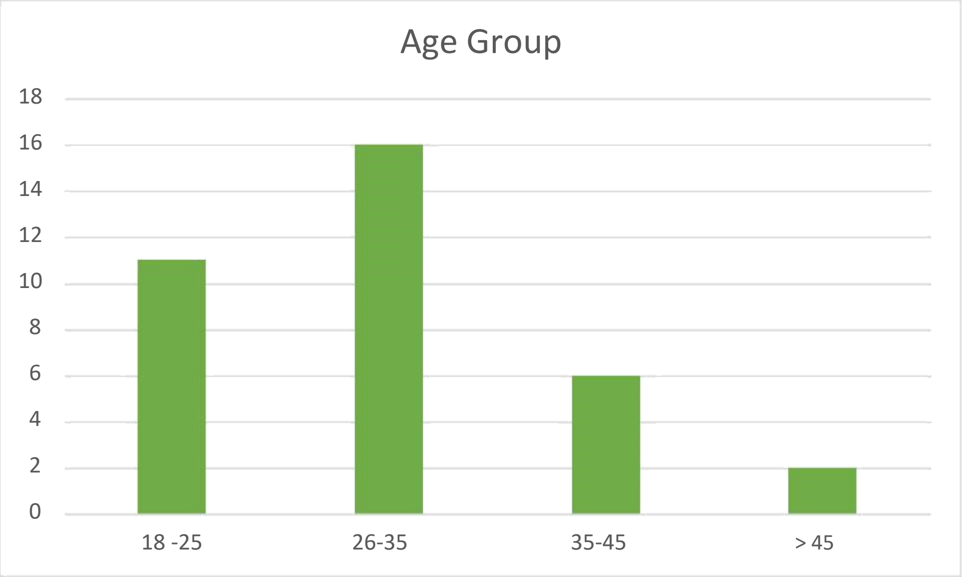


Fig 5.11: Age Group

5.4.2. 3 Ways used to exchange disease surveillance data with other hospitals

Fig 5.12 below indicates that 49% of the participants were using health programs to exchange disease surveillance data with other hospitals. The observation was then followed by that one of 39% of the respondents who had indicated that the exchange disease surveillance data with other hospitals through other staff members. However, the least respond was observed from only 6% respondents who were not sure of the ways in which they exchange disease surveillance data with others.

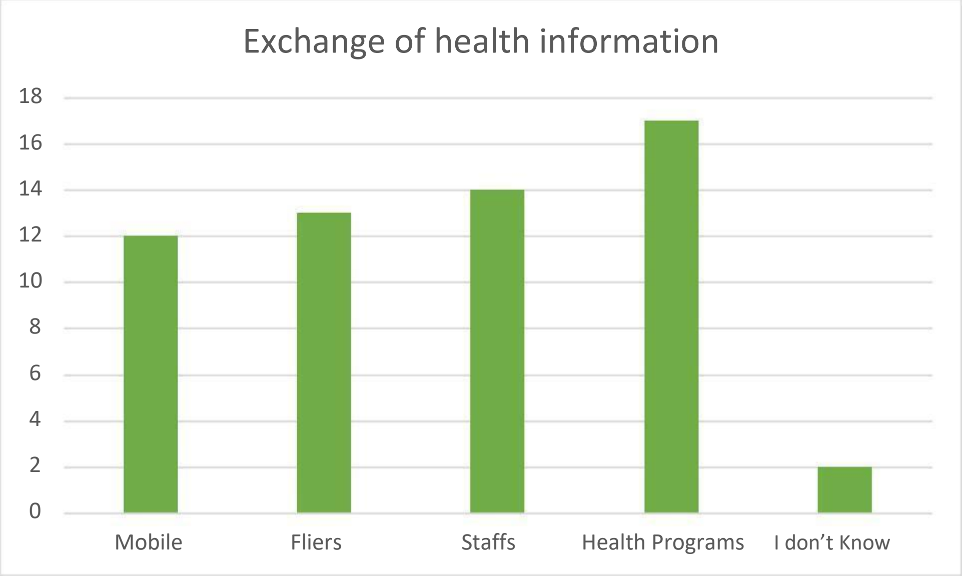


Fig 5.12 Exchanging of health information

5.4.2.4 Accessing disease surveillance data from another public hospitals in Namibia

As shown in fig 5.13, (56%) of the respondents had indicated that they access disease surveillance data from another public hospitals in Namibia through visiting hospitals or clinics. The observation that then followed by 43% of the respondents who had indicated that they access through fliers, while the least responds was obtained from 34% of the respondents who indicated mobile phones.

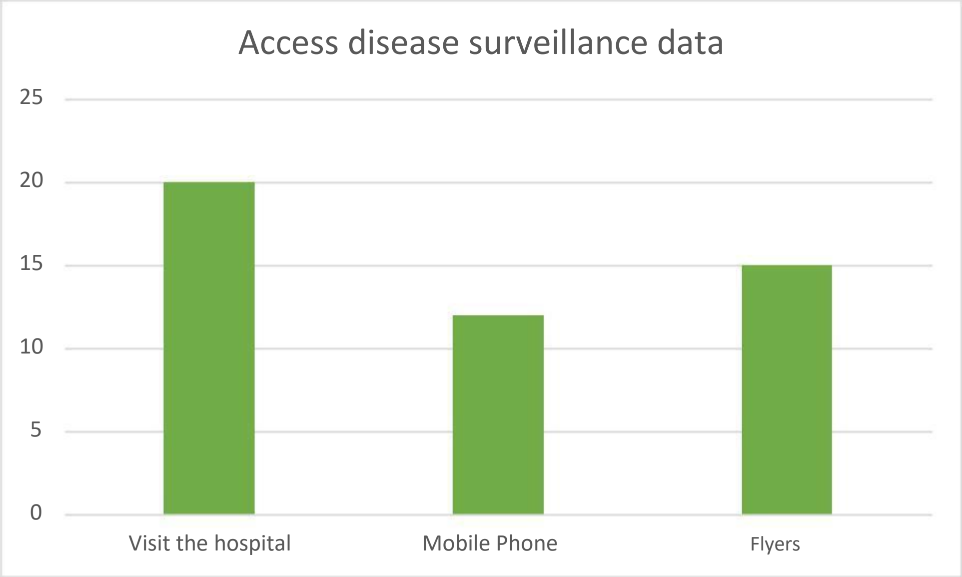


Fig 5.13: Accessing disease surveillance data

5.4.2.5. Type of disease surveillance data exchanged with other public hospitals

When asked about type of disease surveillance data exchange with other public hospitals, 77% of the respondents had indicated that they exchange campaign related data with other public hospitals, while 31% and indicated that exchange their health record data as shown in fig 5.14 below.

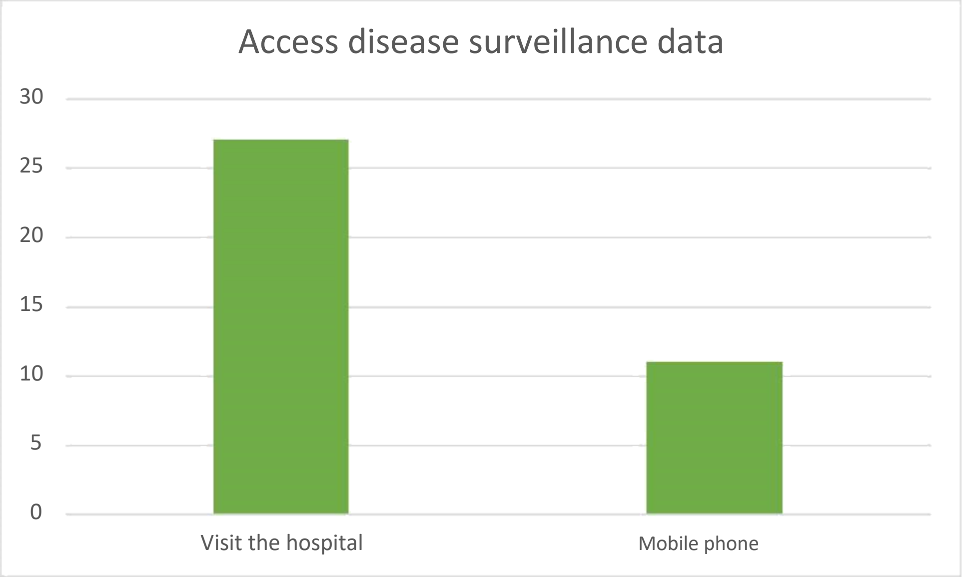


Fig 5.14 Types of disease surveillance data exchanged

5.4.2.6 Type of disease surveillance data exchange with other ICT staffs

Fig 5.15 shows that 63% of the respondents' exchange campaign related to health data with other ICT staffs who works for other organization. The decision was then followed by 29% who indicated that they exchange data which is related to their health record, while 20% had indicated that they exchange other types disease surveillance which were not given from the list.

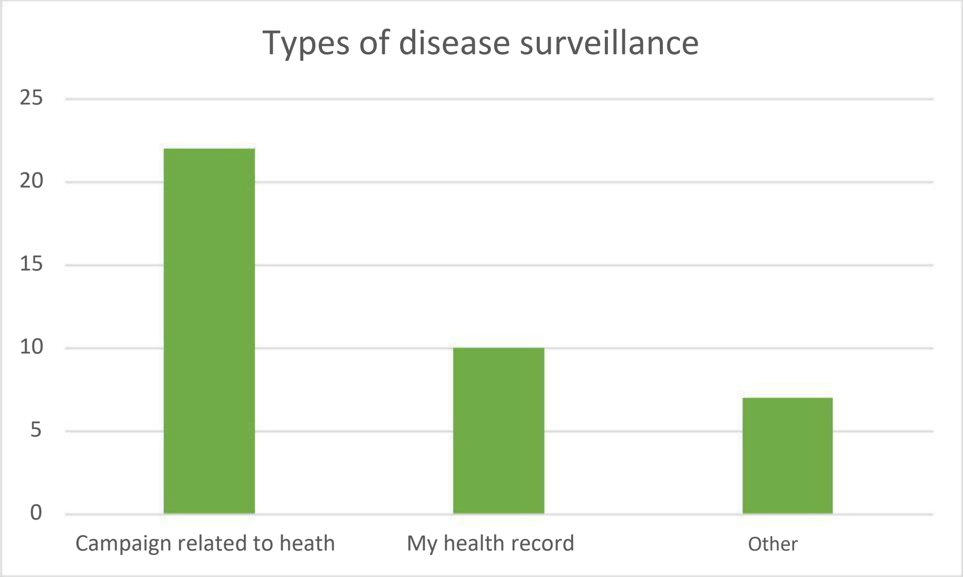


Fig 5.15: Types of disease surveillance

5.4.2.7 Preferred ways of receiving disease surveillance data

Fig 5.16 present preferred ways of receiving disease surveillance data by the respondents. The figure shows that 71% of the respondents prefers visiting the hospitals, followed by 29% of the respondents who preferred mobile phones while the least response was observed from 26% prefers to receive through fliers

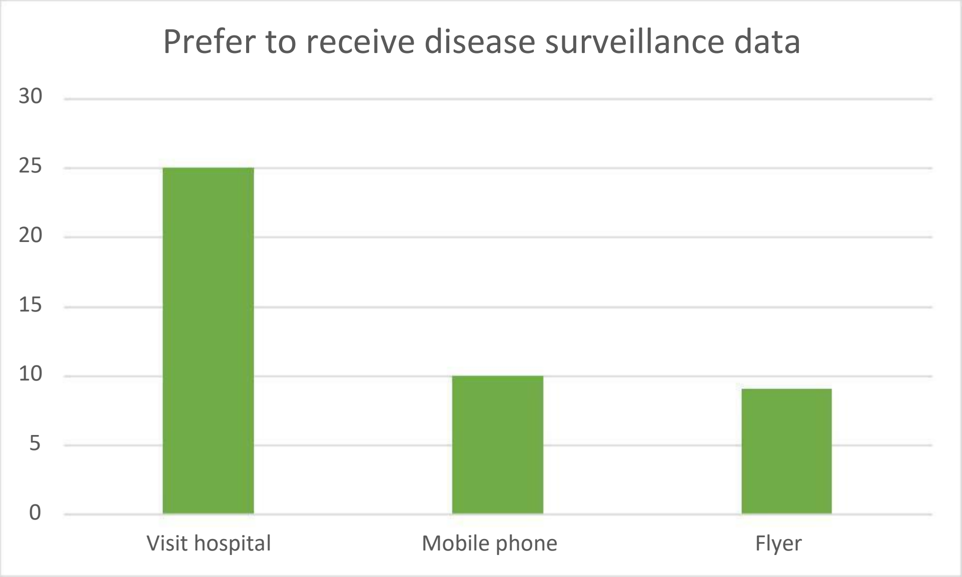


Fig 5.16: Preferred ways of receiving disease surveillance data

5.4.2.8 Types of disease surveillance data would you want to receive from other public hospitals

Fig 5.17 shows that 69% of the respondents want to receive Polio information from other public hospitals. The observation was then followed by 66% who indicated that they want to receive Cancer information. However, the least observation was obtained from 43% of the respondents who indicated that want to receive Ebola information.

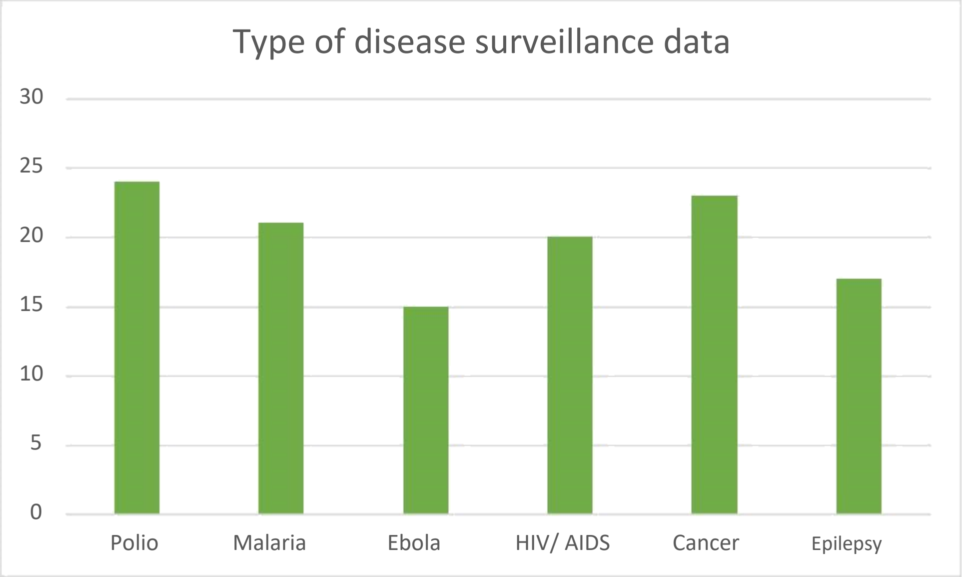


Fig 5.17: Types of disease surveillance

5.4.2.9 Duration to receive the information from other public hospitals

Fig 5.18 portrays a graphical presentation of the time frame taken to accessing disease surveillance data. The highest responses were obtained from 51% of the respondents who indicated that it took a day and 1 to 5 weeks each for them to receive information from other public hospitals. The observations were then followed by 11% of the who indicated that it took them 5 to 10 weeks. However, none of the had indicated that it only takes them a day to access the information from other public hospitals

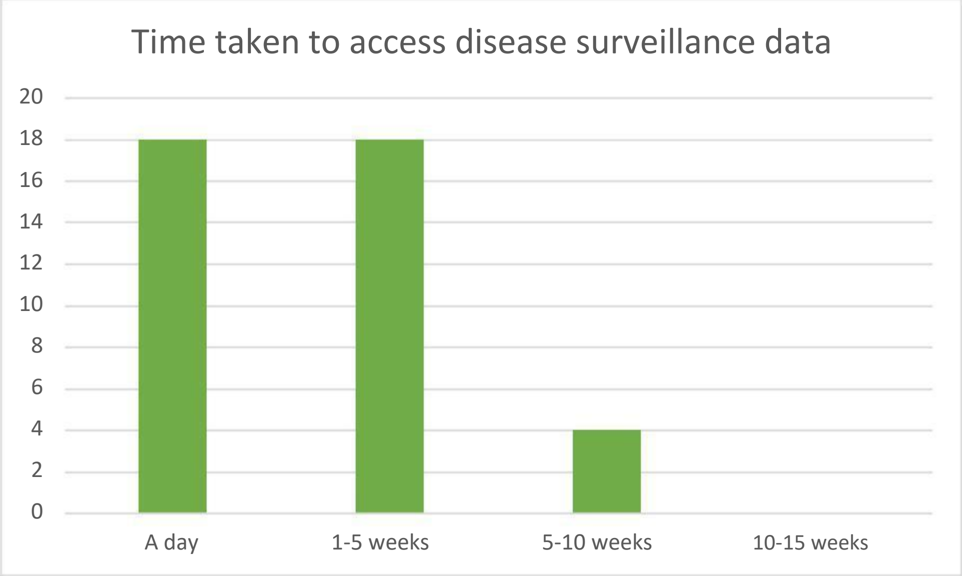


Fig 5.18 Duration to access disease surveillance data

5.4.3 Khomas Region

This section looks at statistics according to gender and age.

5.4.3. 1.Gender

Of the 50 respondents from Karas Region understudy, 54% (n=27) were female respondents, while 46% (n=23) were male respondents as shown in fig 5.19 below.

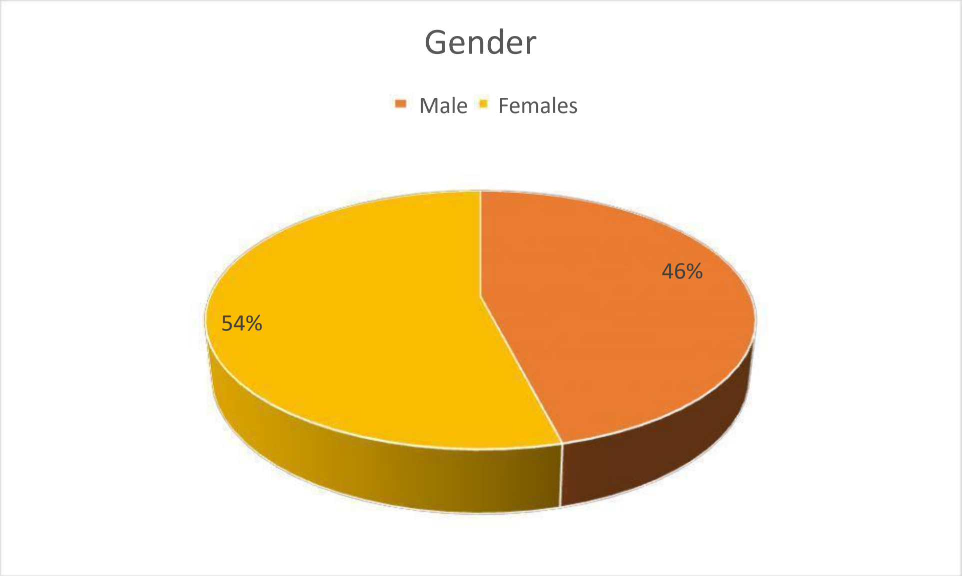


Fig 5.19 Gender

5.4.3.2 Age group

Results in fig 5.20 shows that 42% of the participants in the age group 26-35 year. The observation was then followed by 30% of the participants who were greater than 45 years, while the least observation was obtained from those respondents who were 34-45 year as they were only constituting 12% of the sample in the region.

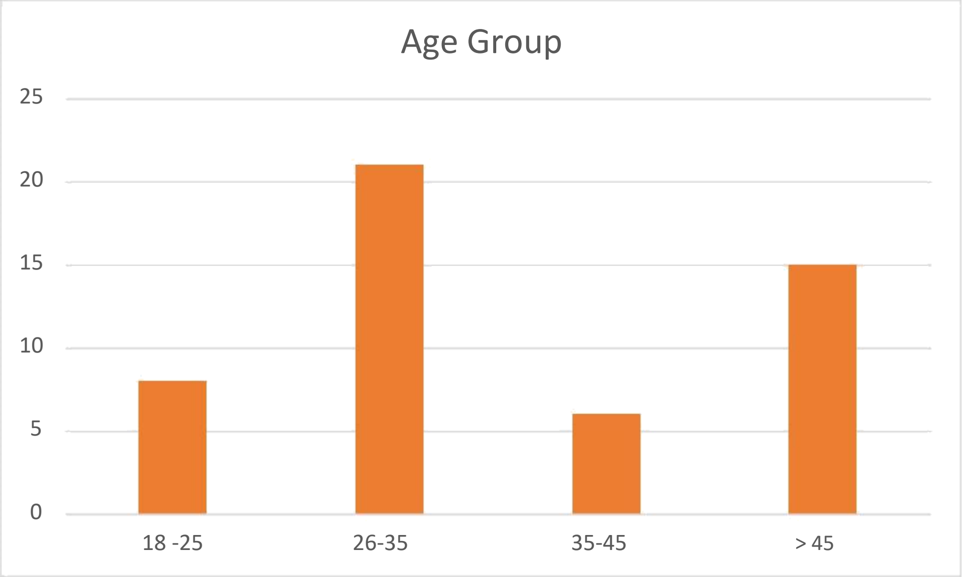


Fig 5.20: Age Group

5.4.3.3 Ways used to exchange disease surveillance data with other hospitals

Fig 5.21 below indicates that 68% of the participants were using fliers to exchange disease surveillance data with other hospitals. The observation was then followed by that one of 54% of the respondents who had indicated that the exchange disease surveillance data through health programs. However, the least respond was observed from only 12% respondents who were not sure of the ways in which they exchange disease surveillance data with others.

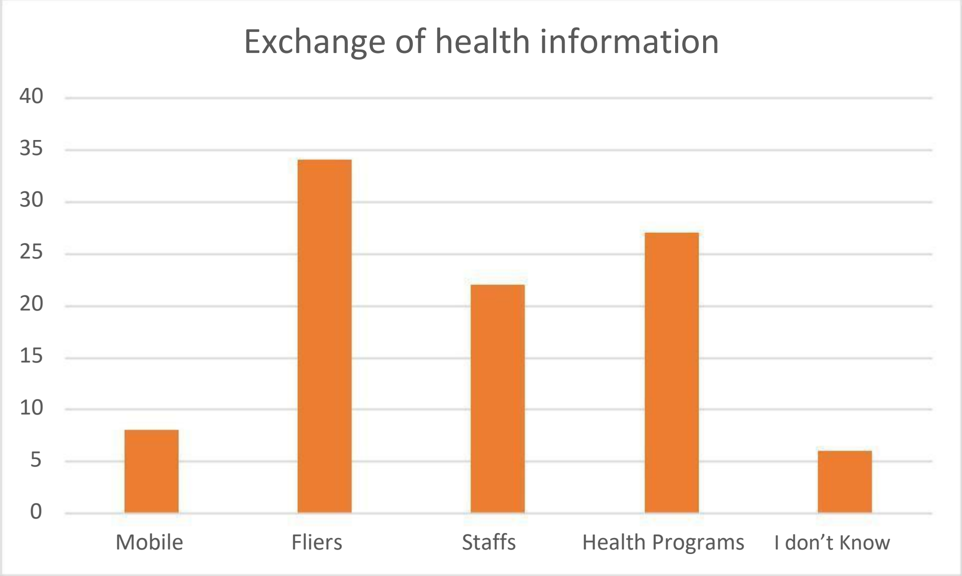


Fig 5.21 Exchanging of health information

5.4.3.4 Accessing disease surveillance data from another public hospitals in Namibia

As shown in fig 5.22, (86%) of the respondents had indicated that they access disease surveillance data from another public hospitals in Namibia through visiting hospitals or clinics. The observation that then followed by 44% of the respondents who had indicated that they access through fliers, while the least responds was obtained from 14% of the respondents who indicated mobile phones.

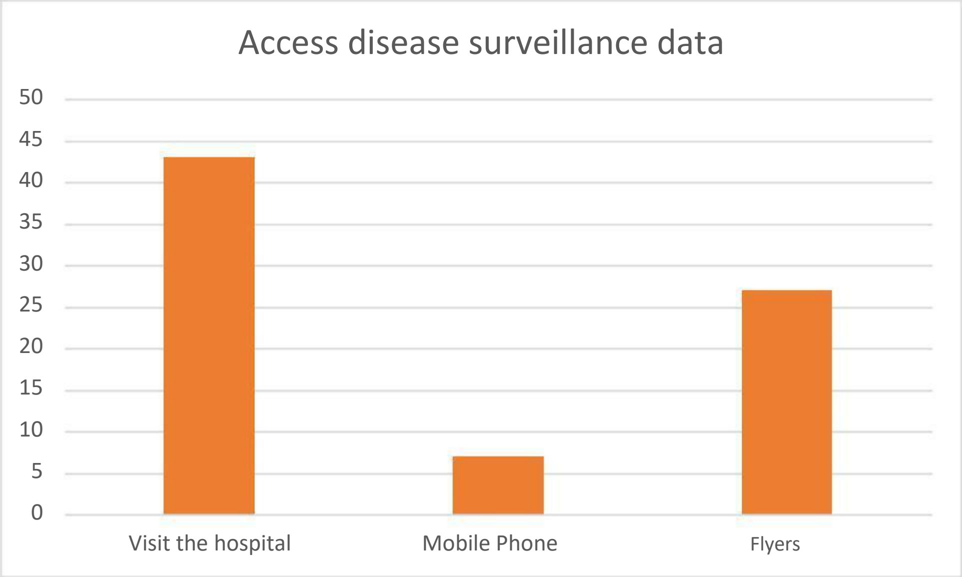


Fig 5.22: Accessing disease surveillance data

5.4.3.5. Type of disease surveillance data exchanged with other public hospitals

When asked about type of disease surveillance data exchange with other public hospitals, 52% of the respondents had indicated that they exchange their health record data with other public hospitals, while 48% and indicated that exchange the campaign related to health data as shown in fig 5.23 below.

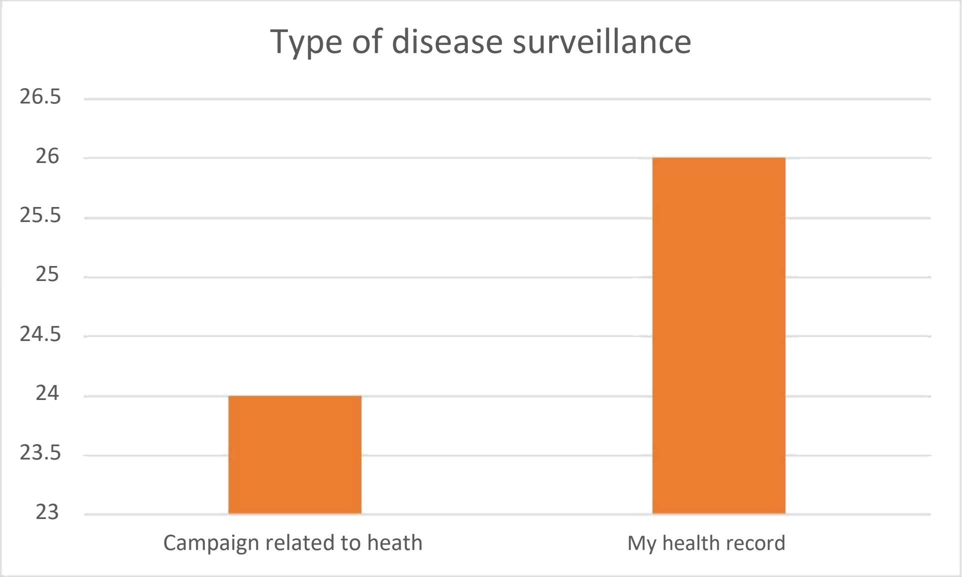


Fig 5.23 Types of disease surveillance data exchanged

5.4.3.6 Preferred ways of receiving disease surveillance data

Fig 5.24 present preferred ways of receiving disease surveillance data by the respondents. The figure shows that 62% of the respondents prefers visiting the hospitals, followed by 36% of the respondents who preferred fliers while the least response was observed from 32% prefers to receive through mobile phones.

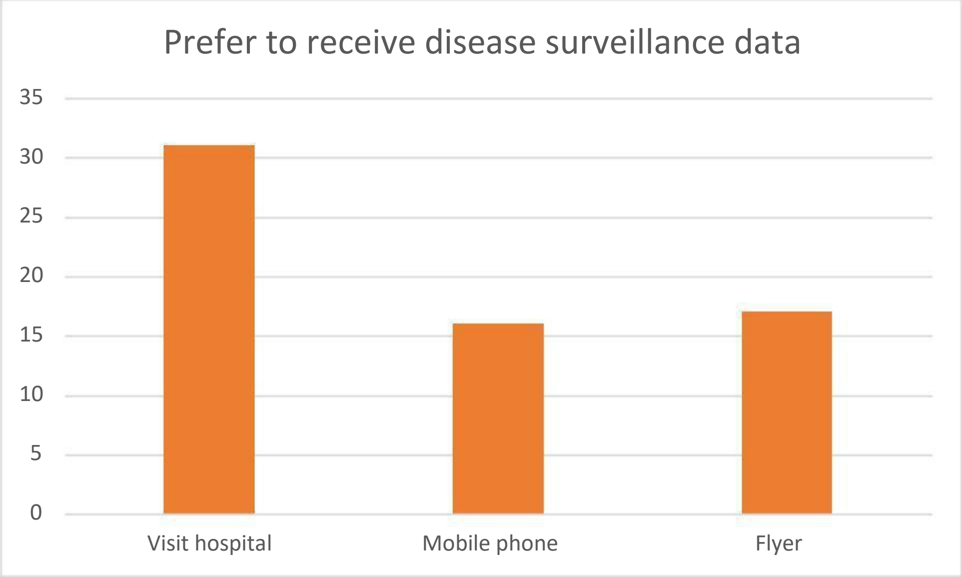


Fig 5.24: Preferred ways of receiving disease surveillance data

5.4.3.7 Types of disease surveillance data would you want to receive from other public hospitals

Fig 5.25 shows that 88% of the respondents want to receive HIV/AIDS information from other public hospitals. The observation was then followed by 74% who indicated that they want to receive Cancer information. However, the least observation was obtained from 46% of the respondents who indicated that want to receive Ebola information.

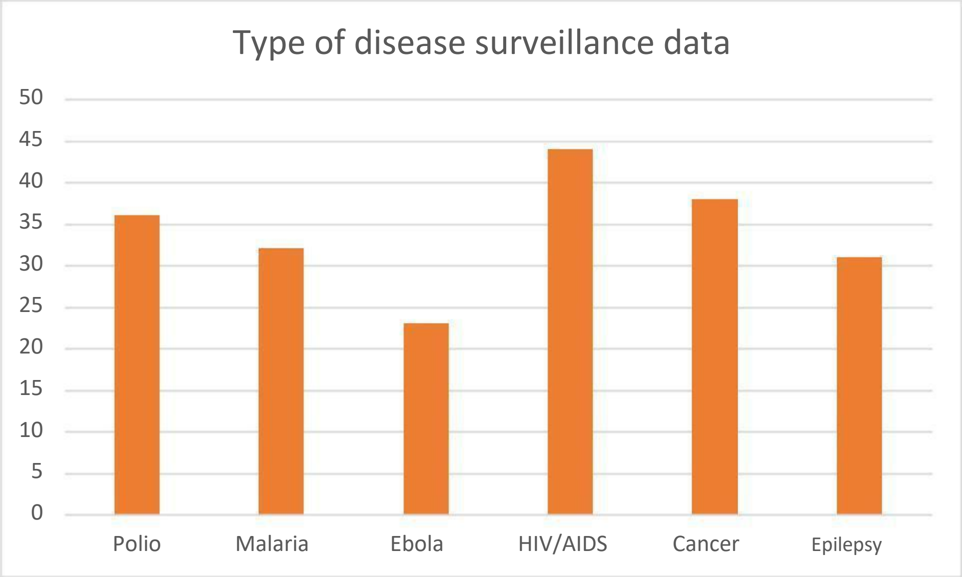


Fig 5.25: Types of disease surveillance

5.4.3.8. Accessing disease surveillance data how long does it take you to receive the information from other public hospitals

Fig 5.26 portrays a graphical presentation of the time frame taken to accessing disease surveillance data. The highest responses were obtained from 54% of the respondents who indicated that it took 1 to 5 weeks to receive information from other public hospitals. The observations were then followed by 50% of the who indicated that it took them 5 to 10 weeks, while the least observation was obtained from 14% of the respondents who had indicated that it only takes them a day to access the information from other public hospitals.

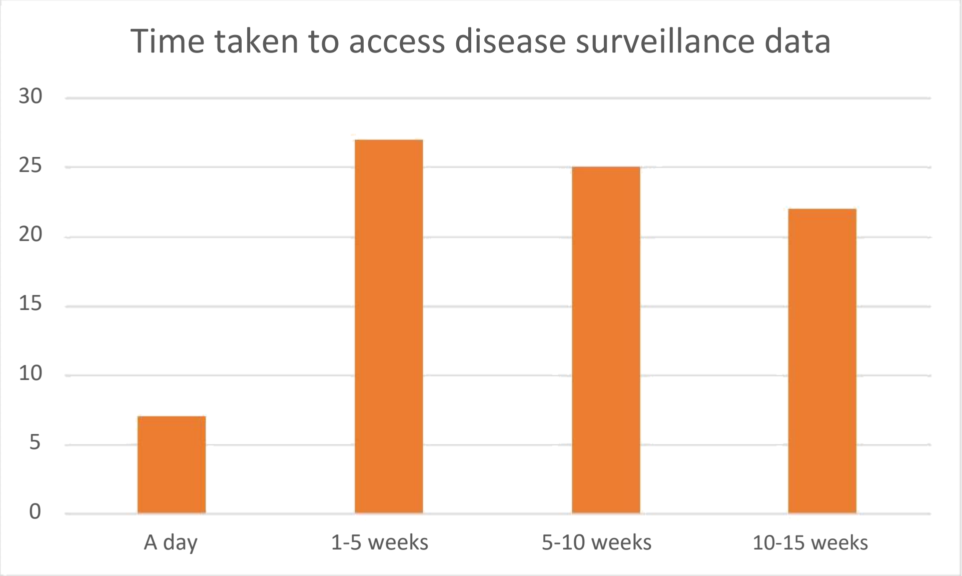


Fig 5.26 Duration to access disease surveillance data

5.4.4 Omusati Region

This section looks at statistics according to gender and age.

5.4.4.1. Gender

Of the 27 respondents from Omusati Region understudy, 52% (n=14) were male respondents, while 48% (n=13) were female respondents as shown in fig 5.26 below.

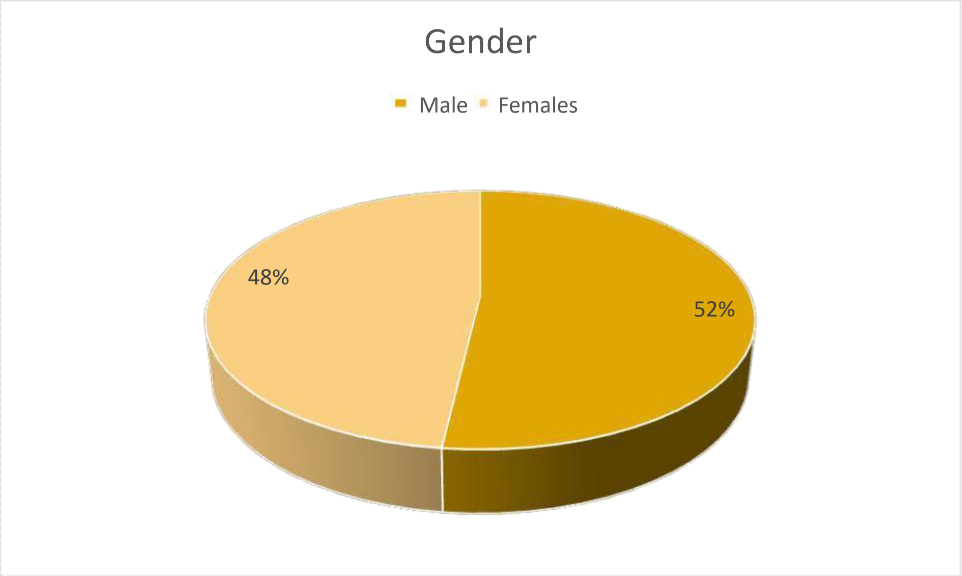


Fig 5.26 Gender

5.4.4.2 Age group

Results in fig 5.27 shows that 48% of the participants in the age group 26-35 years. The observation was then followed by 30% of the participants whom were in the age group 35-45 years, while the least observation was obtained from those respondents who were above 45 as they were only constituting 19% of the sample in the region.

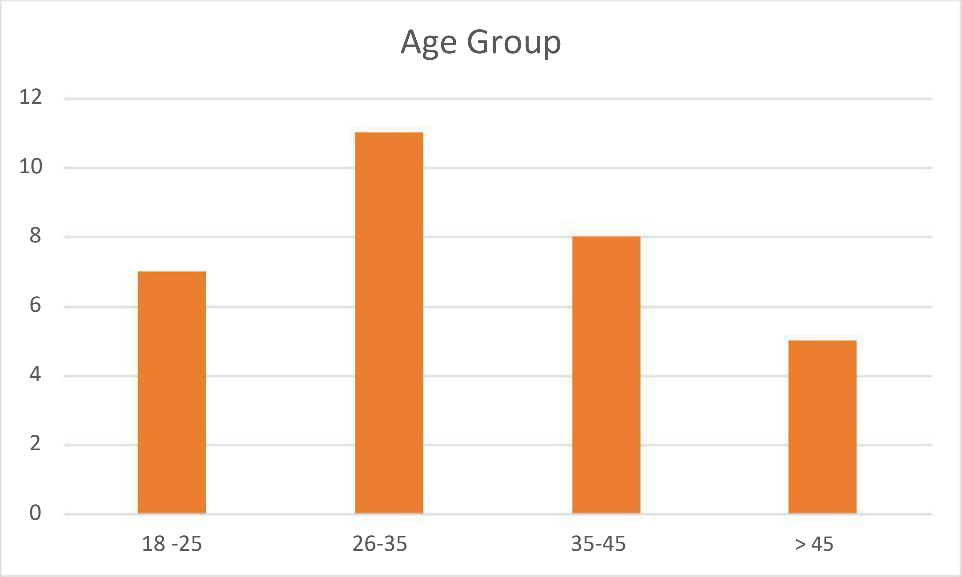


Fig 5.27: Age Group

5.4.4.3 Ways used to exchange disease surveillance data with other hospitals

Fig 5.28 below indicates that 70% of the participants were using health programs to exchange disease surveillance data with other hospitals. The observation was then followed by that one of 56% of the respondents who had indicated that the exchange disease surveillance data with other hospitals fliers. However, the least respond was observed from only 19% respondents who were not sure of the ways in which they exchange disease surveillance data with others.

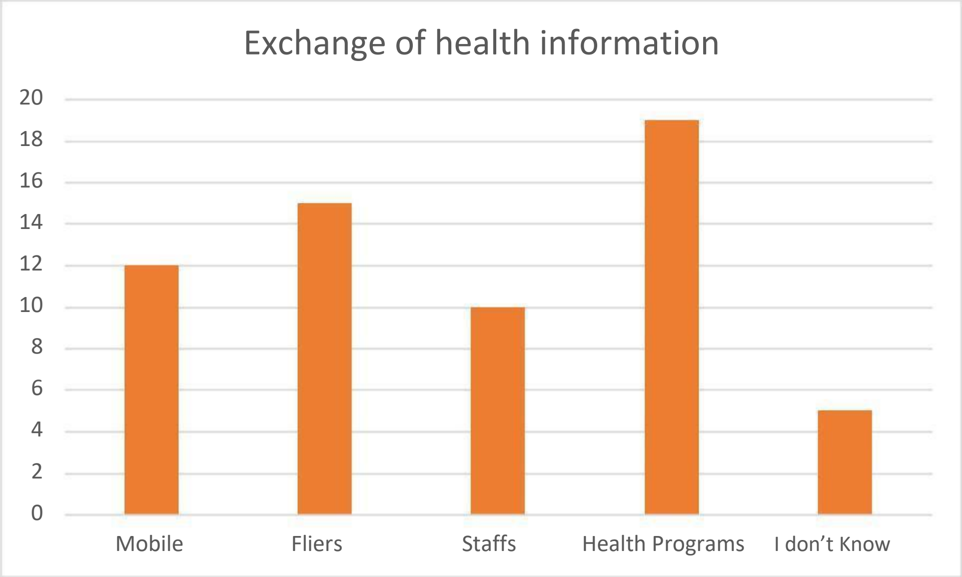


Fig 5.28 Exchanging of health information

5.4.4.4 Accessing disease surveillance data from another public hospitals in Namibia

As shown in fig 5.29, (70%) of the respondents had indicated that they access disease surveillance data from another public hospitals in Namibia through visiting hospitals or clinics. The observation was then followed by 59% of the respondents who had indicated that they access through mobile phones, while the least responds was obtained from 37% of the respondents who indicated fliers.

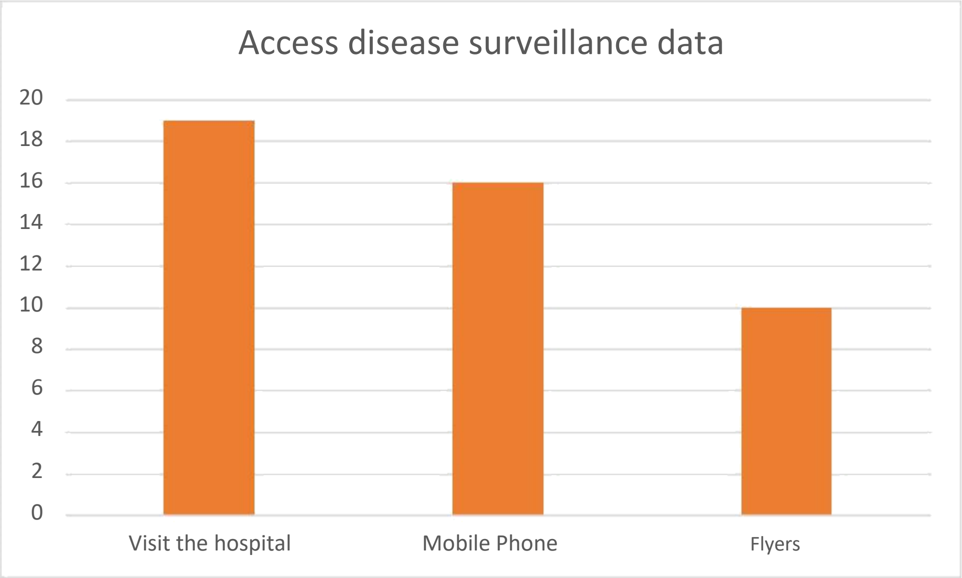


Fig 5.29: Accessing disease surveillance data

5.4.4.5. Type of disease surveillance data exchanged with other public hospitals

When asked about type of disease surveillance data exchange with other public hospitals, 96% of the respondents had indicated that they exchange campaign related data with other public hospitals, while 48% and indicated that exchange their health record data as shown in fig 5.30 below.

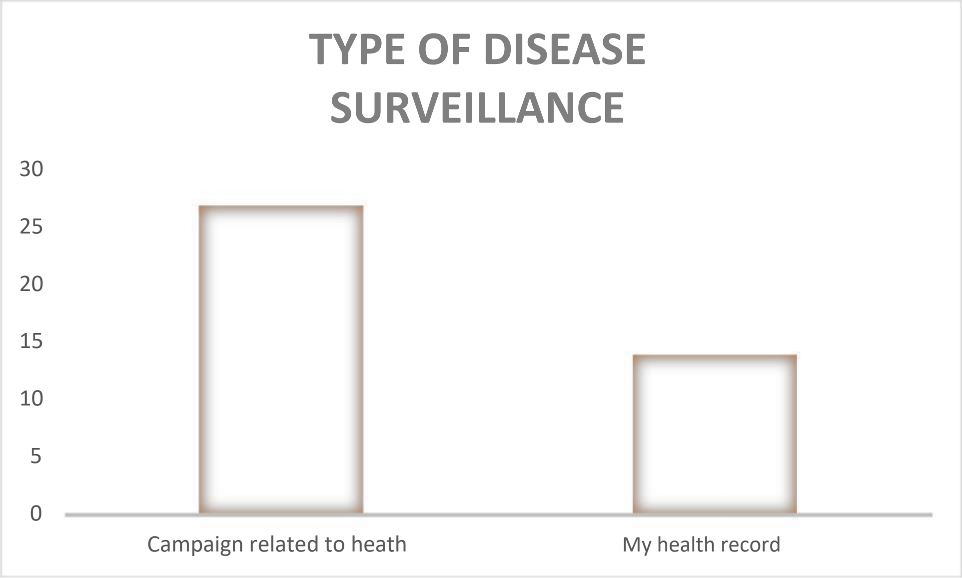


Fig 5.30 Types of disease surveillance data exchanged

5.4.4.6 Preferred ways of receiving disease surveillance data

Fig 5.31 present preferred ways of receiving disease surveillance data by the respondents. The figure shows that 96% of the respondents prefers visiting the hospitals, followed by 52% of the respondents who preferred mobile phones while the least response was observed from 33% who prefers to receive through fliers

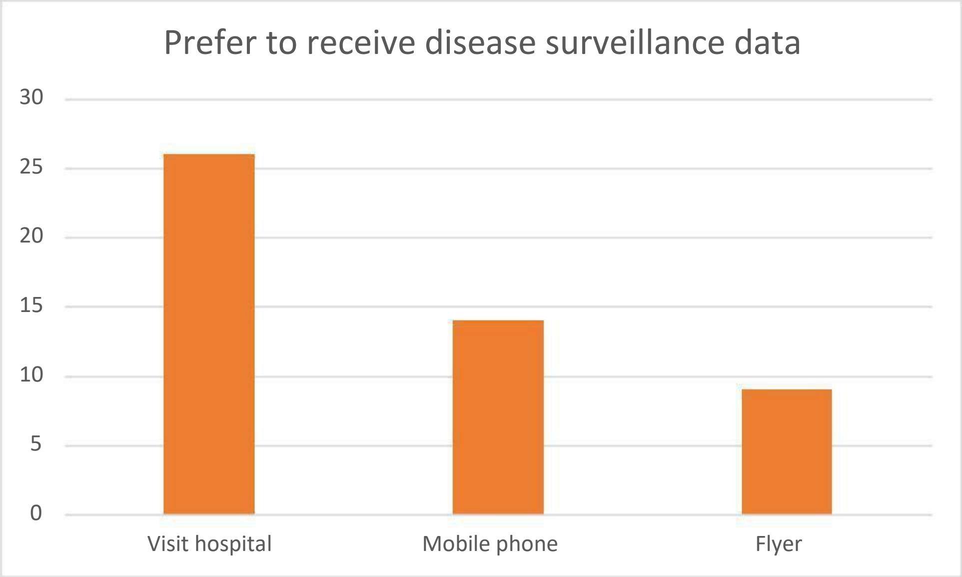


Fig 5.31: Preferred ways of receiving disease surveillance data

5.4.4.7 Types of disease surveillance data would you want to receive from other public hospitals

Fig 5.32 shows that 81% of the respondents want to receive Polio information from other public hospitals. The observation was then followed by 78% who indicated that they want to receive Cancer information. However, the least observation was obtained from 41% of the respondents who indicated that want to receive Ebola information.

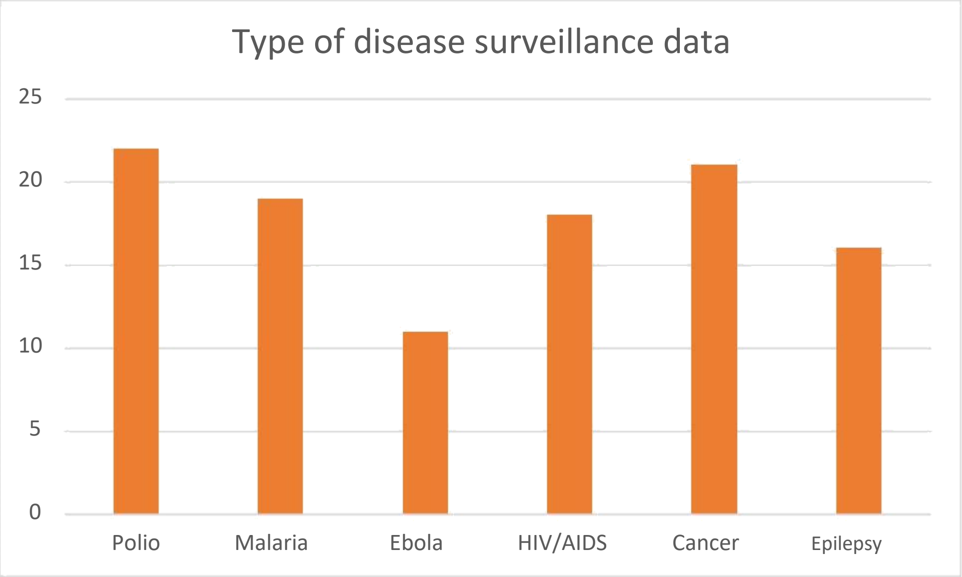


Fig 5.32: Types of disease surveillance

5.4.4.8 Duration to receive the information from other public hospitals

Fig 5.32 portrays a graphical presentation of the time frame taken to accessing disease surveillance data. The highest responses were obtained from 51% of the respondents who indicated that it took a day and 1 to 5 weeks each for them to receive information from other public hospitals. The observations were then followed by 44% of the who indicated that it took them a day, while 7% had indicated that it only takes them 5 to 10 weeks to access the information from other public hospitals

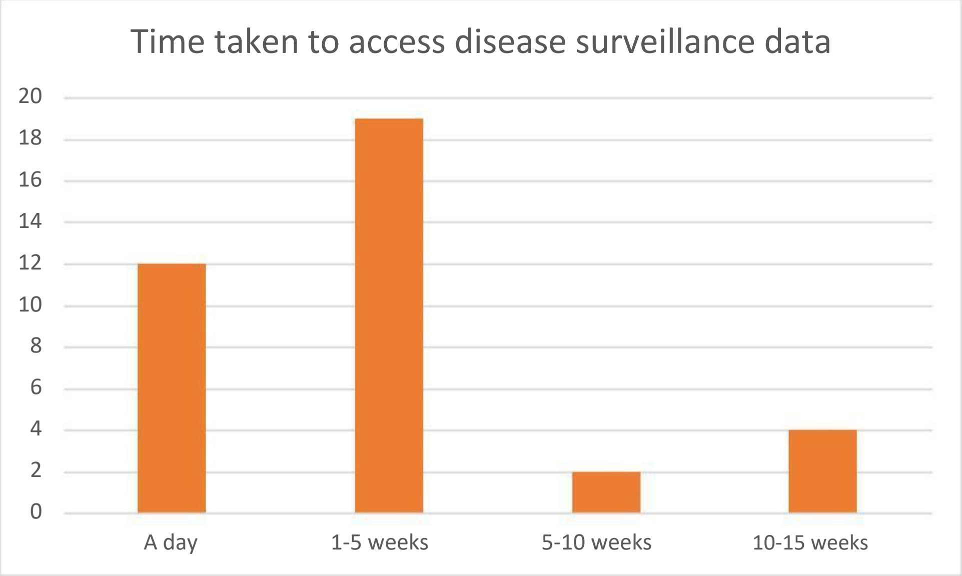


Fig 5.32 Duration to access disease surveillance data

5.4.5 Kunene Region

This section looks at statistics according to gender and age.

5.4.5.1. Gender

Of the 39 respondents from Kunene Region understudy, 59% (n=23) were male respondents, while 41% (n=16) were female respondents as shown in fig 5.33 below.

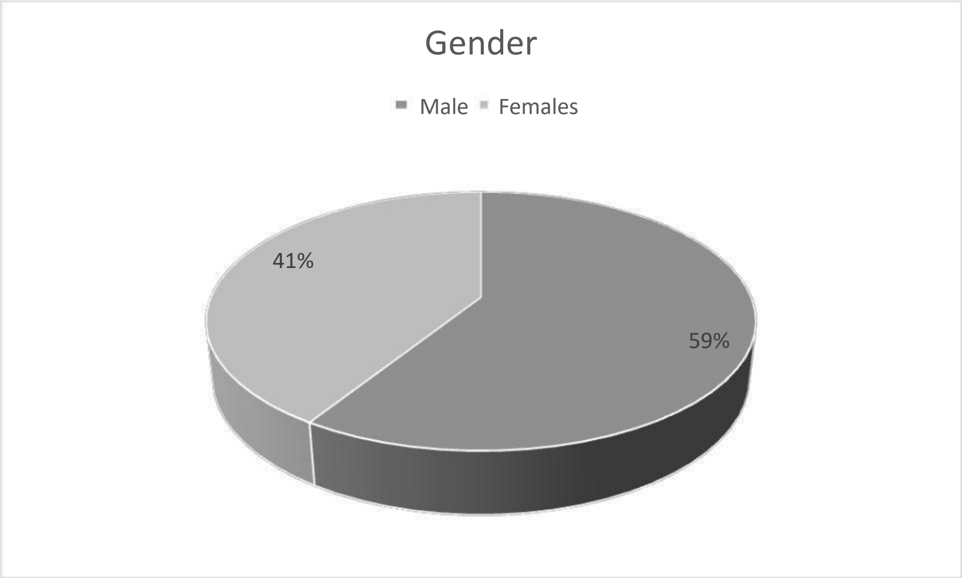


Fig 5.33 Gender

5.4.5.2 Age group

Results in fig 5.34 shows that 41% of the participants in the age group 26-35 years. The observation was then followed by 33% of the participants whom were in the age group 35-45 years, while the least observation was obtained from those respondents who were in the age group of 18-25 years as they were only constituting 18% of the sample in the region

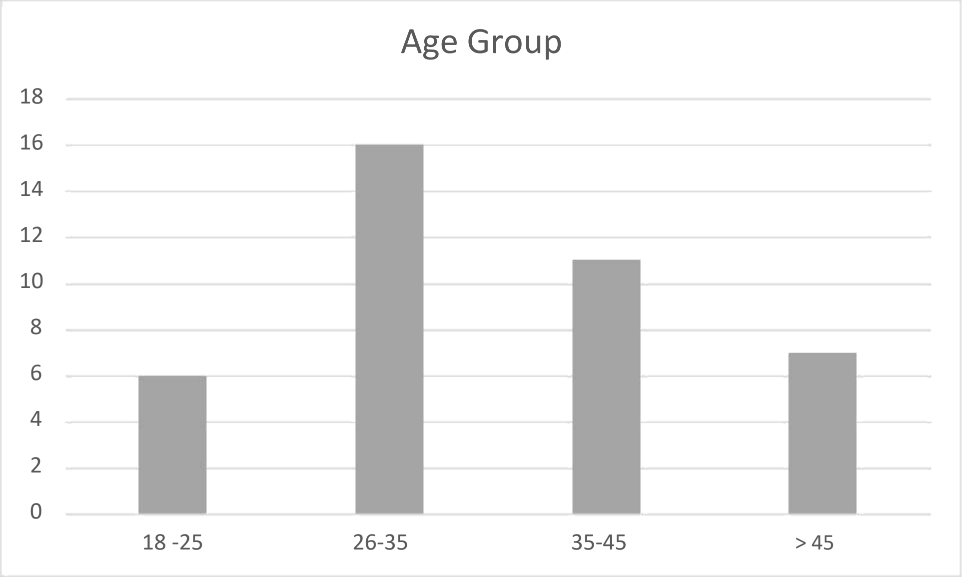


Fig 5.34: Age Group

5.4.5.3 Ways used to exchange disease surveillance data with other hospitals

Fig 5.35 below indicates that 49% of the participants were using health programs to exchange disease surveillance data with other hospitals. The observation was then followed by those respondents who had indicated that the exchange disease surveillance data with other hospitals fliers and staff as they had 41% each of the total representation. However, the least respond was observed from only 8% respondents who were not sure of the ways in which they exchange disease surveillance data with others.

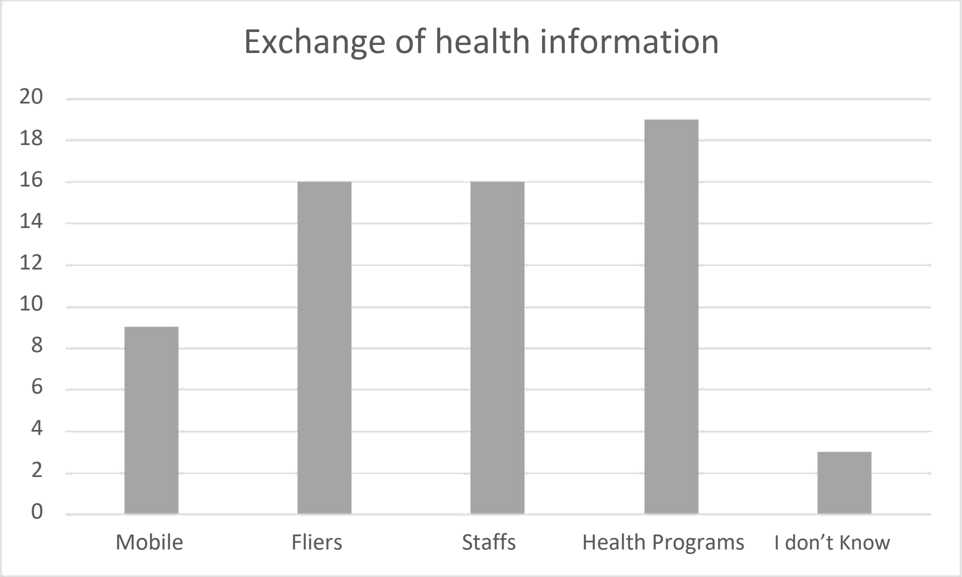


Fig 5.35 Exchanging of health information

5.4.5.4 Accessing disease surveillance data from another public hospitals in Namibia

As shown in fig 5.29, 44% of the respondents had indicated that they access disease surveillance data from another public hospitals in Namibia through visiting hospitals or clinics and fliers each, while the least responds were obtained from 28% of the respondents who indicated mobile phones

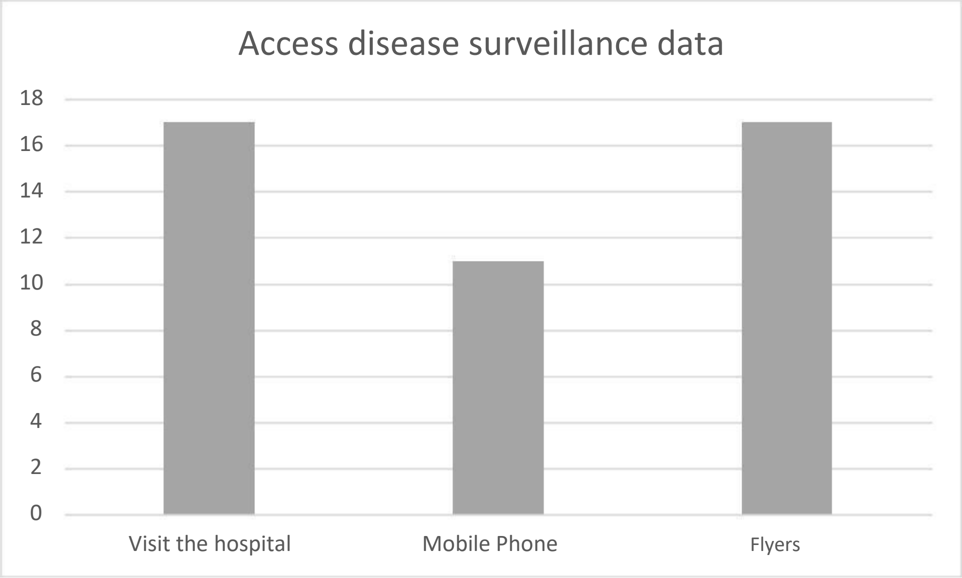


Fig 5.36: Accessing disease surveillance data

5.4.5.5. Type of disease surveillance data exchanged with other public hospitals

When asked about type of disease surveillance data exchange with other public hospitals, 64% of the respondents had indicated that they exchange campaign related data with other public hospitals, while 38% and indicated that exchange their health record data as shown in fig 5.37 below.

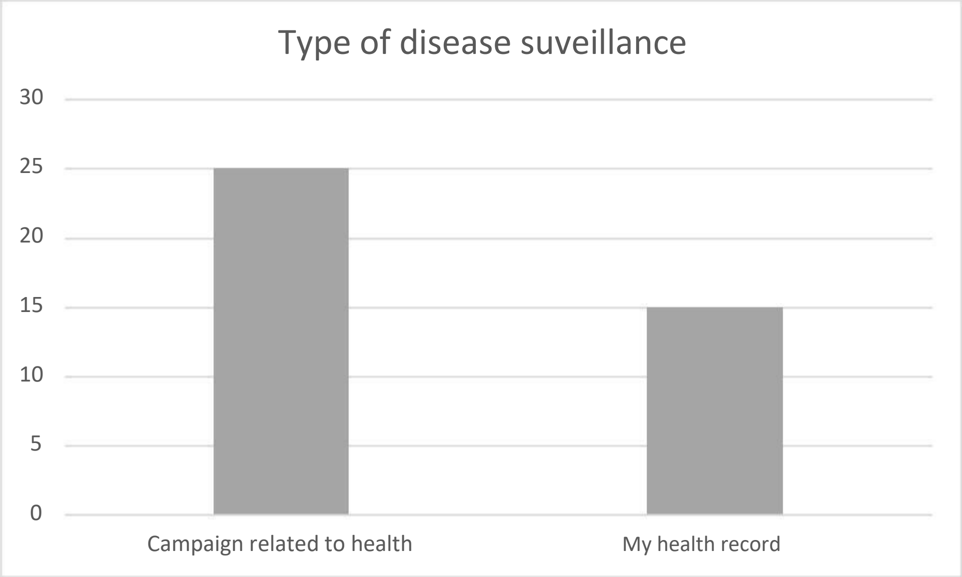


Fig 5.37 Types of disease surveillance data exchanged

5.4.5.6 Preferred ways of receiving disease surveillance data

Fig 5.38 present preferred ways of receiving disease surveillance data by the respondents. The figure shows that 54% of the respondents prefers mobile phones, followed by 46% of the respondents who preferred visiting hospital while the least response was observed from 18% of the sample understudy in the region who prefers to receive through fliers.

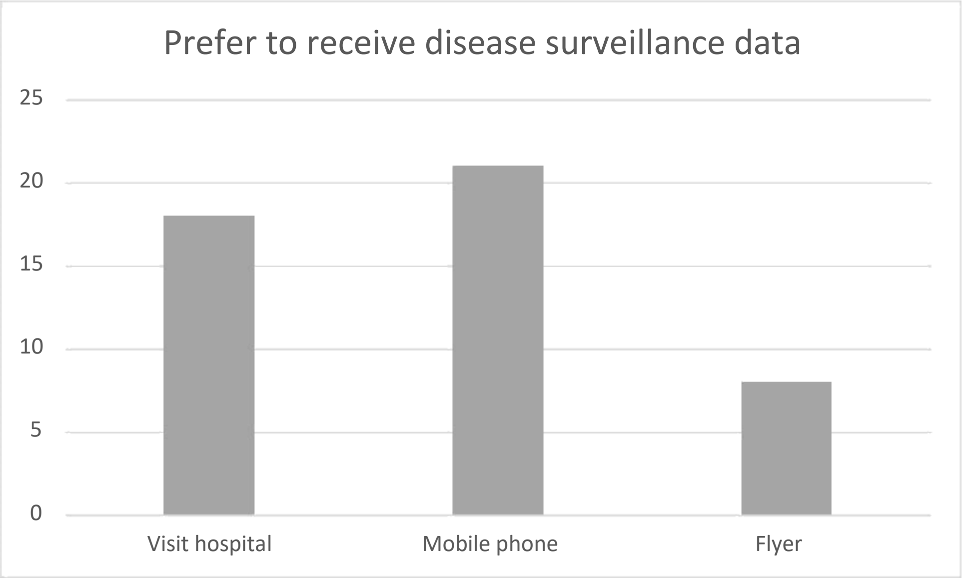


Fig 5.38: Preferred ways of receiving disease surveillance data

5.4.5.7 Types of disease surveillance data would you want to receive from other public hospitals

Fig 5.39 shows that 79% of the respondents want to receive Epilepsy information from other public hospitals. The observation was then followed by those who want to receive Cancer and polio information as they 67% each of the representation. However, the least observation was obtained from 41% of the respondents who indicated that want to receive Ebola information

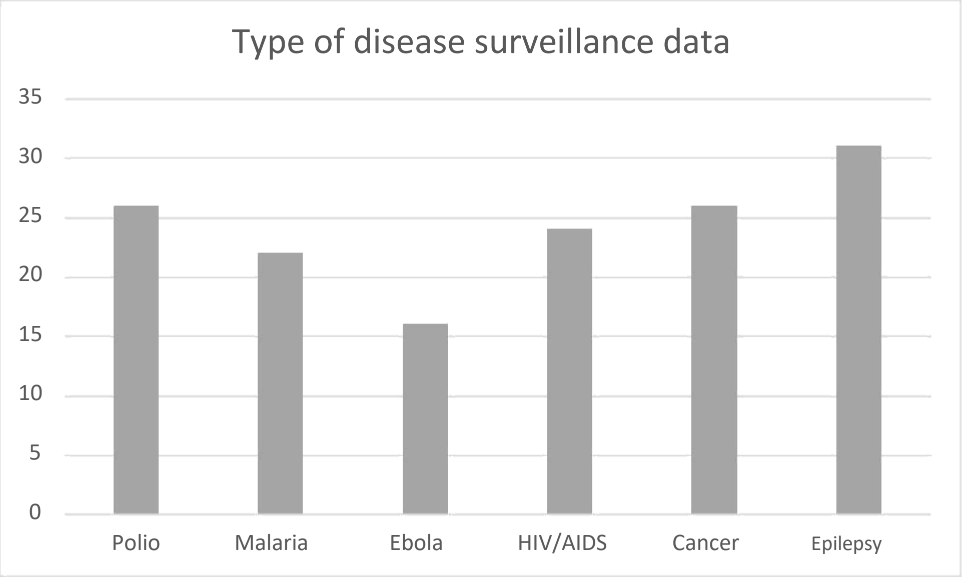


Fig 5.39: Types of disease surveillance

5.4.5.8 Duration to receive the information from other public hospitals

Fig 5.40 portrays a graphical presentation of the time frame taken to accessing disease surveillance data. The highest responses were obtained from 54% of the respondents who indicated that it took a day and 1 to 5 weeks each for them to receive information from other public hospitals. The observations were then followed by 33% of the who indicated that it took them 10-15 weeks, while 18% had indicated that it only takes them 5 to 10 weeks to access the information from other public hospitals.

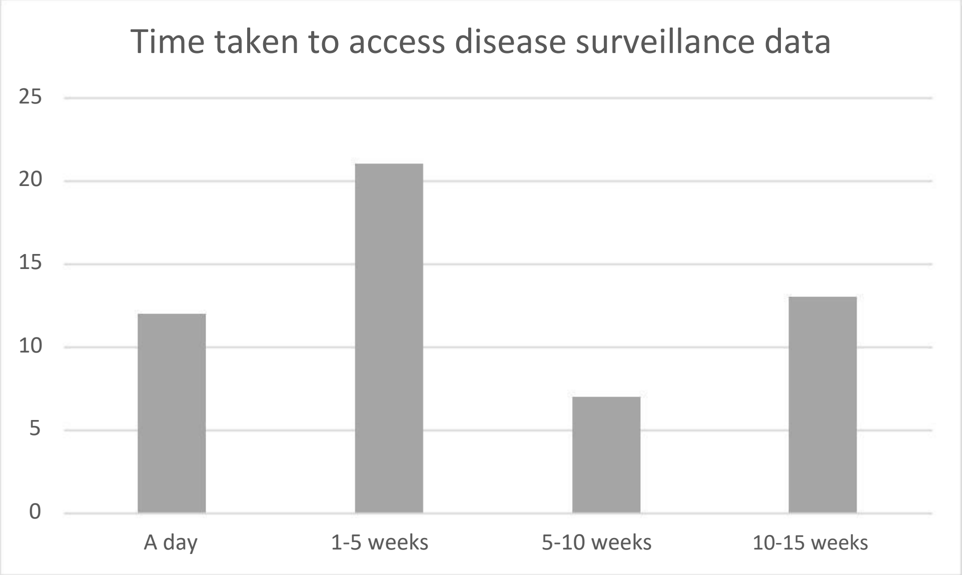


Fig 5.40 Duration to access disease surveillance data

5.4.6 Ohangwena Region

This section looks at statistics according to gender and age.

5.4.6.1. Gender

Of the 37 respondents from Ohangwena Region understudy, 57% (n=21) were male respondents, while 43% (n=16) were female respondents as shown in fig 5.41 below.

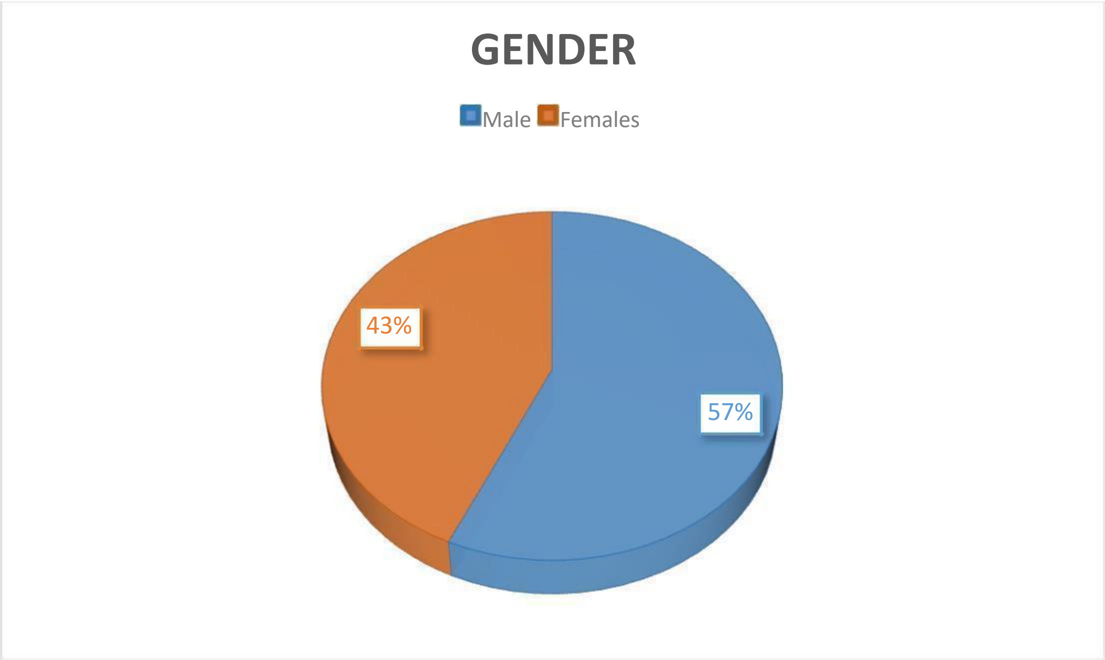


Fig 5.41: Gender

5.4.6.2 Age group

Results in fig 5.42 shows that 59% of the participants in the age group 26-35 years. The observation was then followed by 16% of the participants whom were in the age group 35-45 years, while the least observation was obtained from those respondents who were in the age group of 18-25 years as they were only constituting 11% of the sample in the region

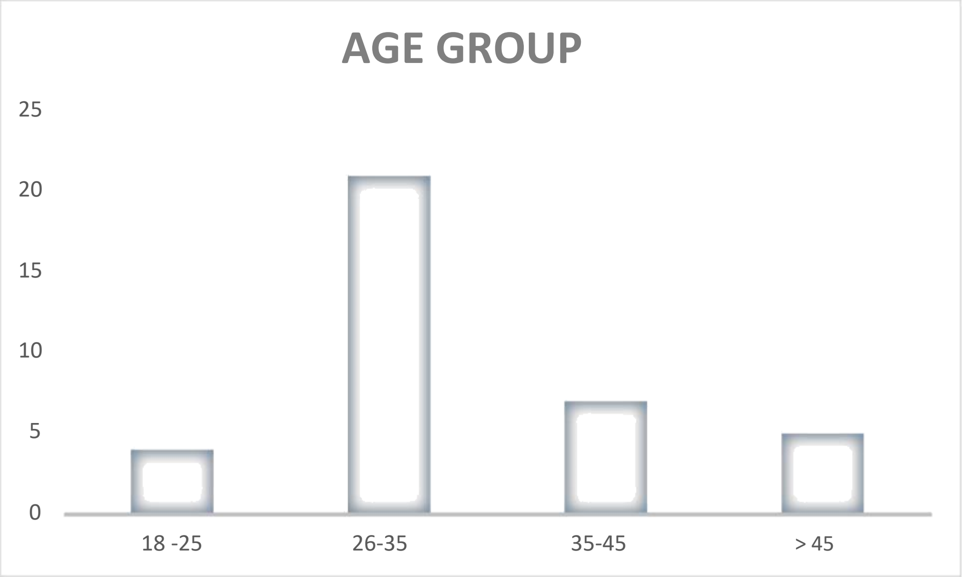


Fig 5.42: Age Group

5.4.6.3 Ways used to exchange disease surveillance data with other hospitals

Fig 5.43 below indicates that 62% of the participants were using health programs to exchange disease surveillance data with other hospitals. The observation was then followed by 54% of the respondents who had indicated that they use fliers to exchange disease surveillance data with other hospitals. However, the least respond was observed from only 11% of the respondents who were not sure of the ways in which they exchange disease surveillance data with others.

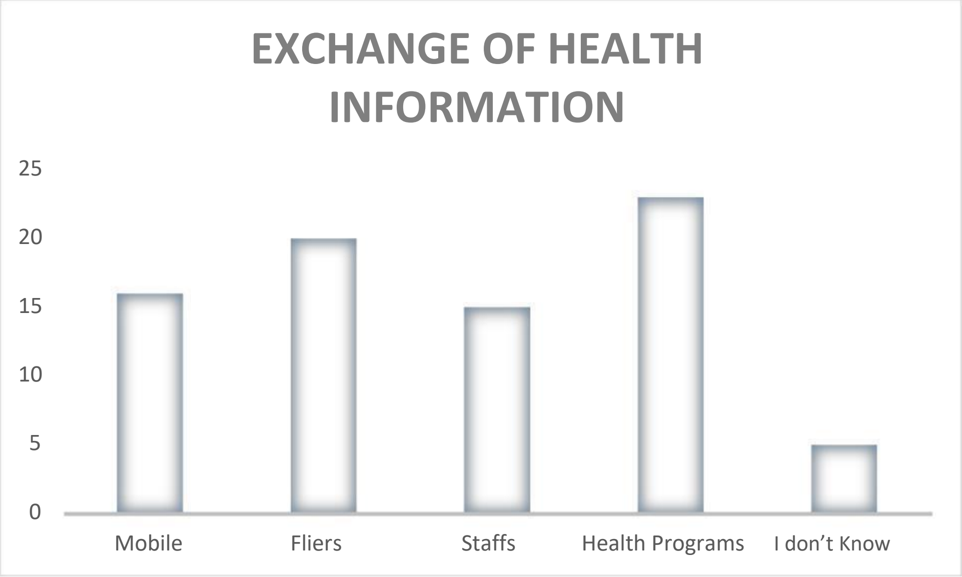


Fig 5.43 Exchanging of health information

5.4.6.4 Accessing disease surveillance data from another public hospitals in Namibia

As shown in fig 5.44, 65% of the respondents had indicated that they access disease surveillance data from another public hospitals in Namibia through visiting hospitals or clinics. The observation was then followed by 37% who indicated mobile phones, while the least responds were obtained from 30% of the respondents who had indicated fliers.

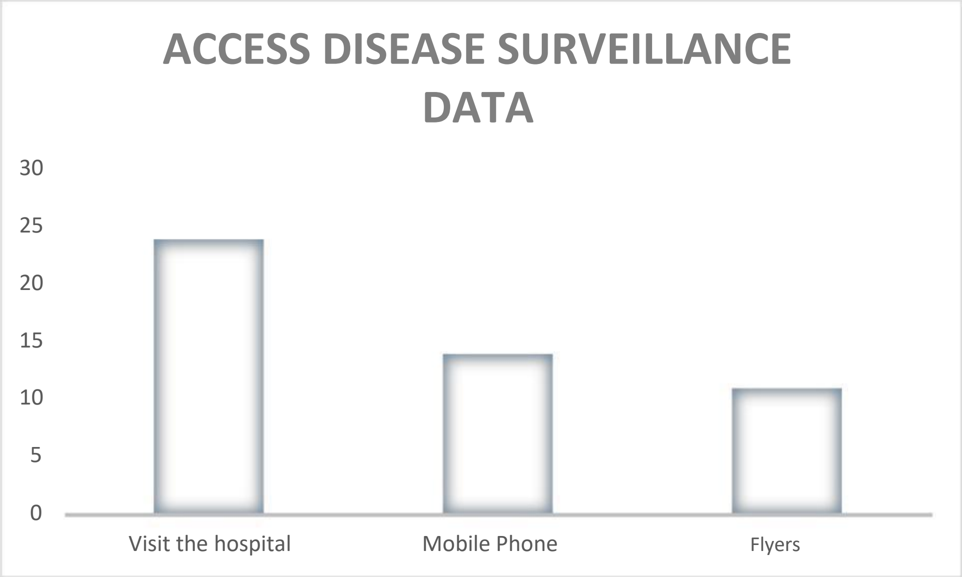


Fig 5.44 Exchanging of health information

5.4.6.5. Type of disease surveillance data exchanged with other public hospitals

When asked about type of disease surveillance data exchange with other public hospitals, 69% of the respondents had indicated that they exchange campaign related data with other public hospitals, while 39% and indicated that exchange their health record data as shown in fig 5.45 below.

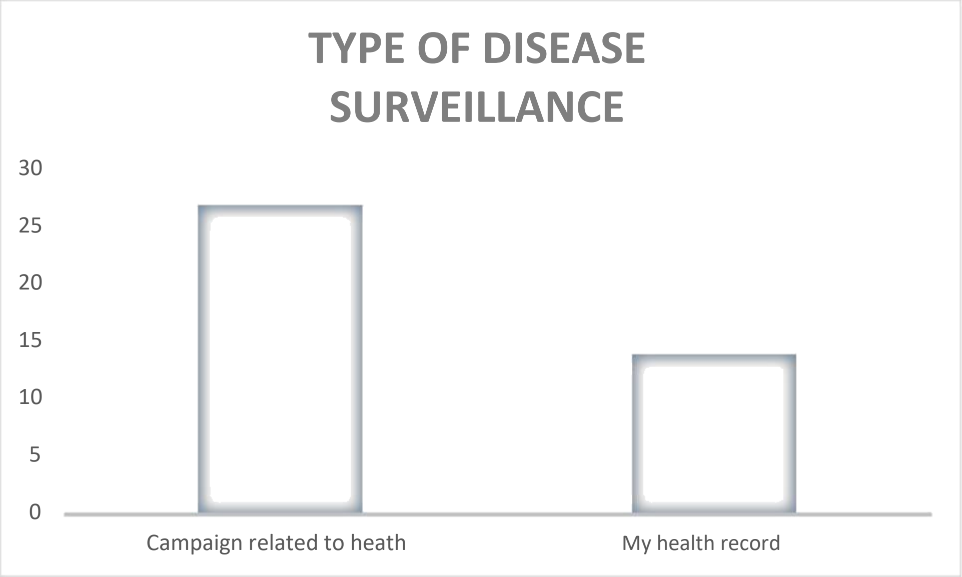


Fig 5.45 Types of disease surveillance data exchanged

5.4.6.6 Preferred ways of receiving disease surveillance data

Fig 5.38 present preferred ways of receiving disease surveillance data by the respondents. The figure shows that 68% of the respondents prefers visiting hospital, followed by 43% of the respondents who preferred mobile phones while the least response was observed from 16% of the sample understudy in the region who prefers to receive through fliers.

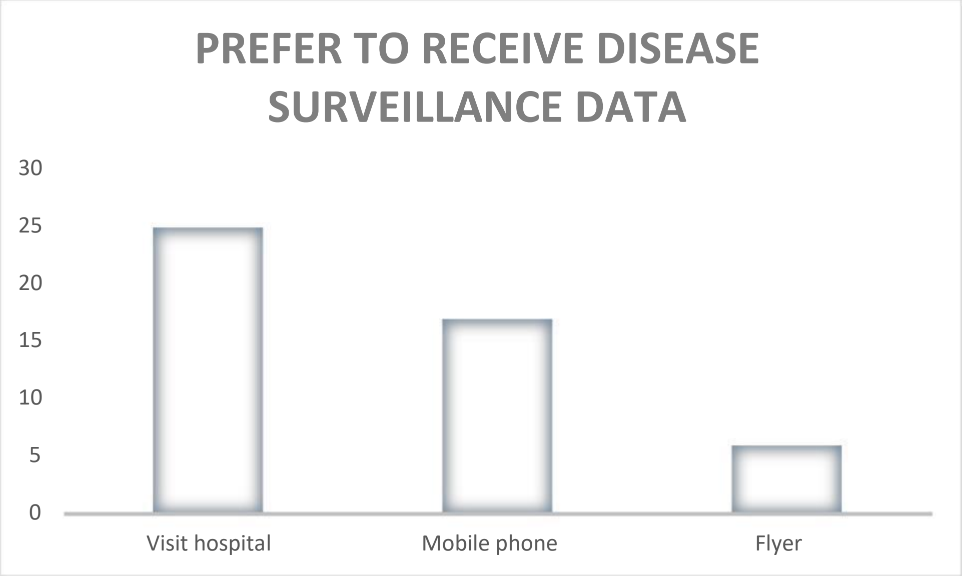


Fig 5.46: Preferred ways of receiving disease surveillance data

5.4.6.7 Types of disease surveillance data would you want to receive from other public hospitals

Fig 5.47 shows that 81% of the respondents want to receive HIV/ AIDS information from other public hospitals. The observation was then followed by 76% of the sample understudy who want to receive Malaria information. However, the least observation was obtained from 35% of the respondents who indicated that want to receive Epilepsy information.

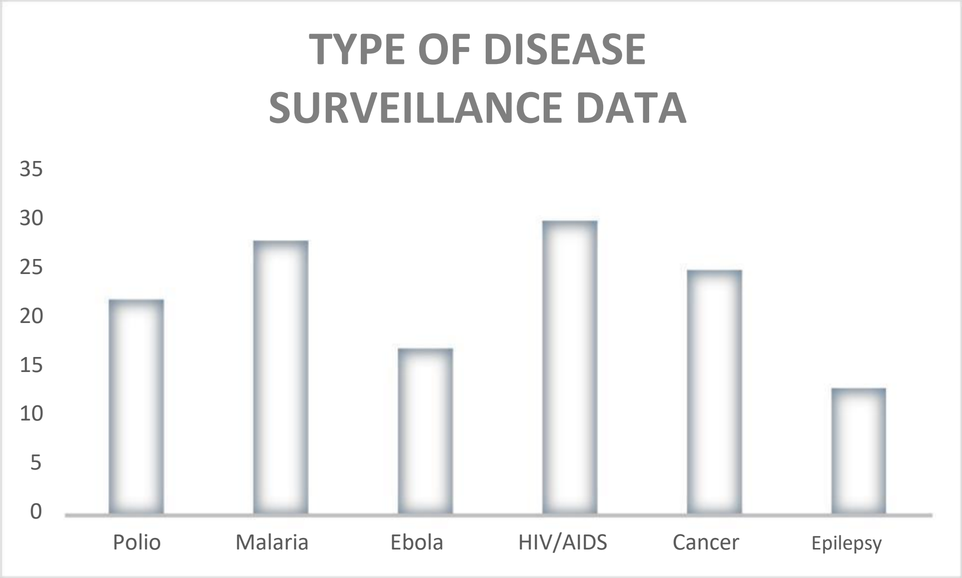


Fig 5.47: Types of disease surveillance

5.4.6.8 Duration to receive the information from other public hospitals

Fig 5.48 portrays a graphical presentation of the time frame taken to accessing disease surveillance data. The highest responses were obtained from 65% of the respondents who indicated that it took a day and 1 to 5 weeks each for them to receive information from other public hospitals. The observations were then followed by 38% of the who indicated that it took them 5-10 weeks, while 30% had indicated that it only takes them 10-15 weeks to access the information from other public hospitals.

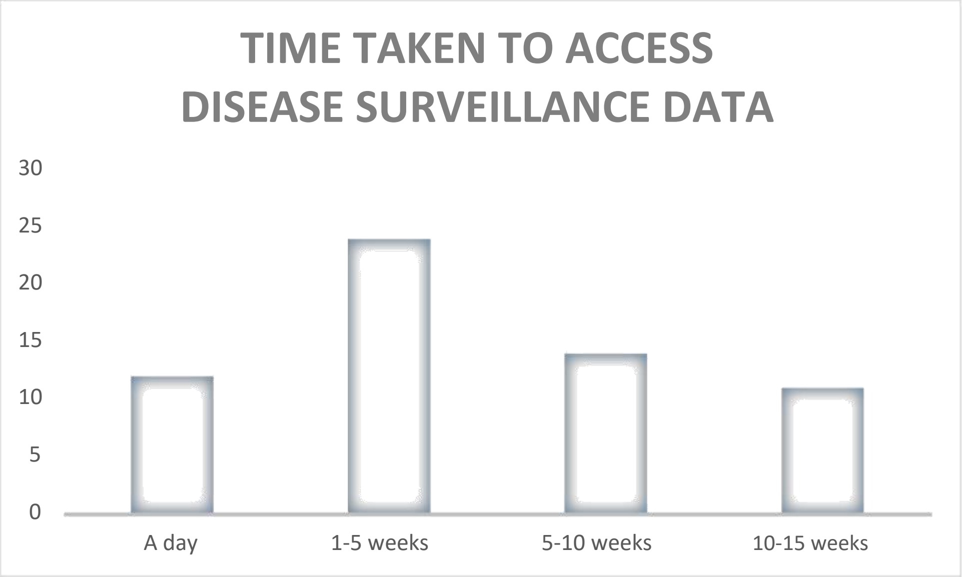


Fig 5.48 Duration to access disease surveillance data

5.4.7 Otjondupa Region

This section looks at statistics according to gender and age.

5.4.7.1. Gender

Of the 29 respondents from Otjondupa Region understudy, 55% (n=16) were male respondents, while 45% (n=13) were female respondents as shown in fig 5.49 below

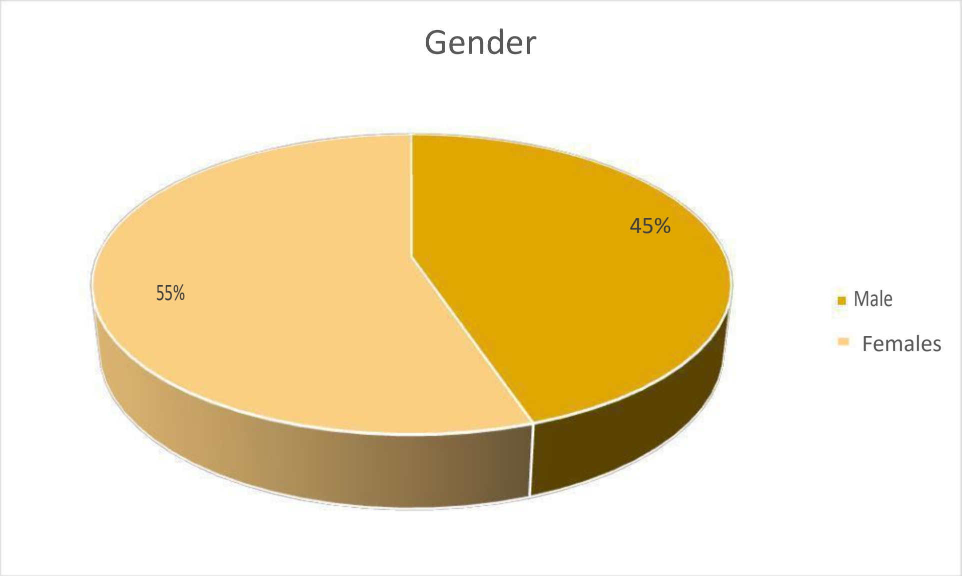


Fig 5.49: Gender

5.4.7.2 Age group

Results in fig 5.50 shows that 38% of the participants in the age group 26-35 years. The observation was then followed by 28% of the participants whom were in the age group 35-45 years, while the age group 18-25 and were having 17% each of the total representation in the region.

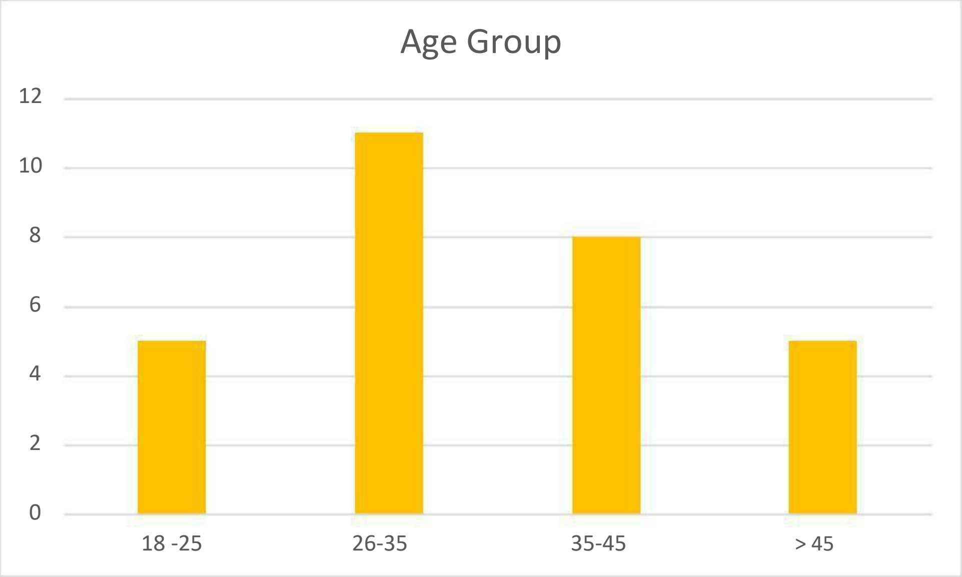


Fig 5.50: Age Group

5.4.6.3 Ways used to exchange disease surveillance data with other hospitals

Fig 5.51 below indicates that 66% of the participants were using staffs to exchange disease surveillance data with other hospitals. The observation was then followed by those who indicated mobiles and health programs as they each have 59% of the respondents who had indicated that they use mobile phones and health programs to exchange disease surveillance data with other hospitals. However, none of the respondents was not sure of the ways in which they exchange disease surveillance data with others.

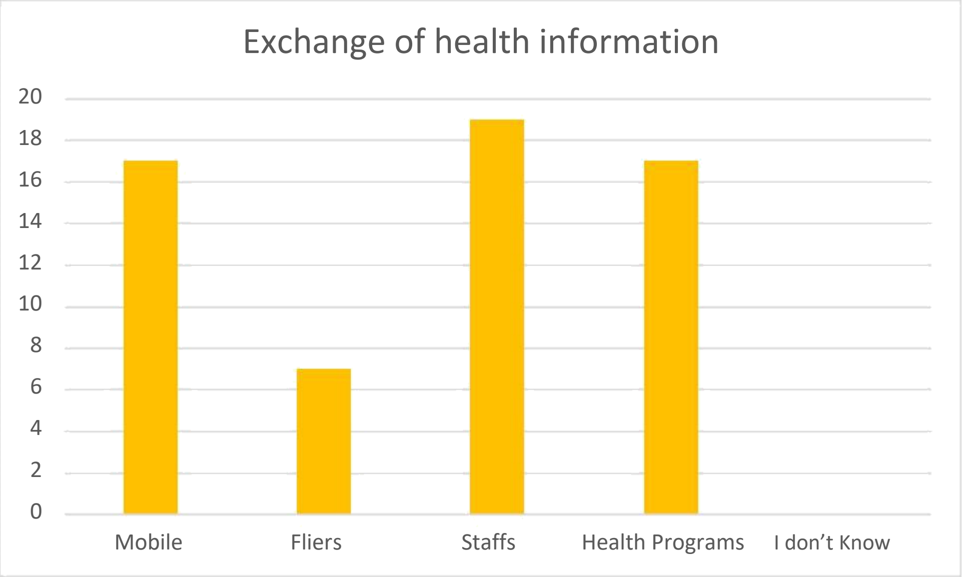


Fig 5.51 Exchanging of health information

5.4.7.4 Accessing disease surveillance data from another public hospitals in Namibia

As shown in fig 5.52, 65% of the respondents had indicated that they access disease surveillance data from another public hospitals in Namibia through visiting hospitals or clinics. The observation was then followed by 37% who indicated mobile phones, while the least responds were obtained from 30% of the respondents who had indicated fliers.

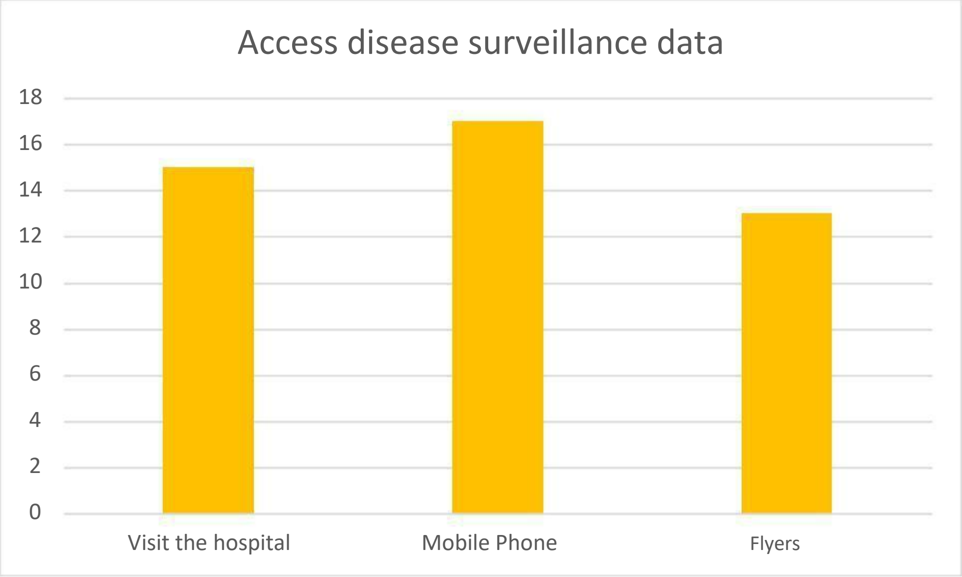


Fig 5.52 Exchanging of health information

5.4.7.5. Type of disease surveillance data exchanged with other public hospitals

When asked about type of disease surveillance data exchange with other public hospitals, 69% of the respondents had indicated that they exchange campaign related data with other public hospitals, while 39% and indicated that exchange their health record data as shown in fig 5.53 below.

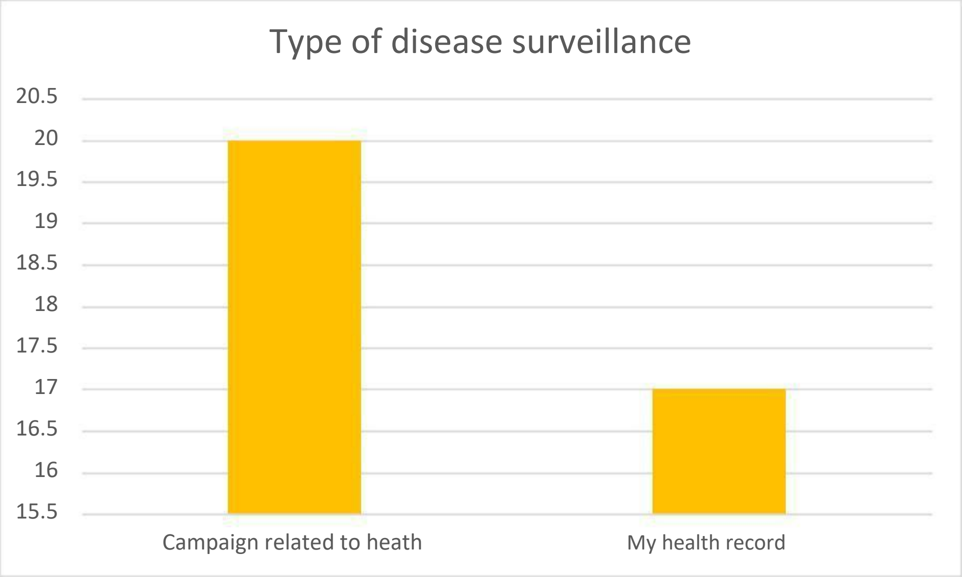


Fig 5.53 Types of disease surveillance data exchanged

5.4.7.6 Preferred ways of receiving disease surveillance data

Fig 5.54 present preferred ways of receiving disease surveillance data by the respondents. The figure shows that 66% of the respondents prefers visiting hospital, followed by 62% of the respondents who preferred mobile phones while the least response was observed from 17% of the sample understudy in the region who prefers to receive through fliers.

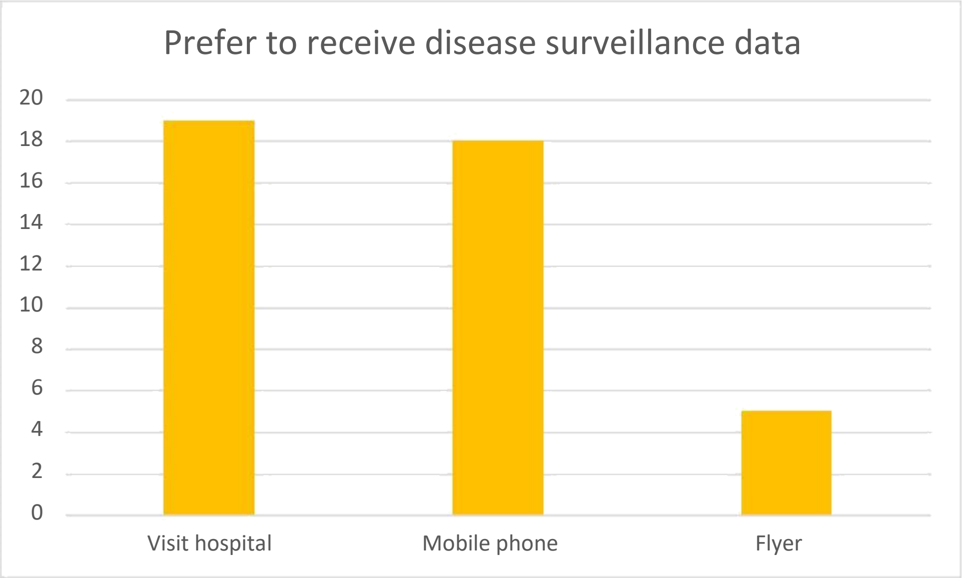


Fig 5.54: Preferred ways of receiving disease surveillance data

5.4.6.7 Types of disease surveillance data would you want to receive from other public hospitals

Fig 5.55 shows that 66% of the respondents want to receive HIV/ AIDS information from other public hospitals. The observation was then followed by Polio and Malaria who had each 76% of the sample understudy. However, the least observation was obtained from 28% of the respondents who indicated that want to receive Ebola information.

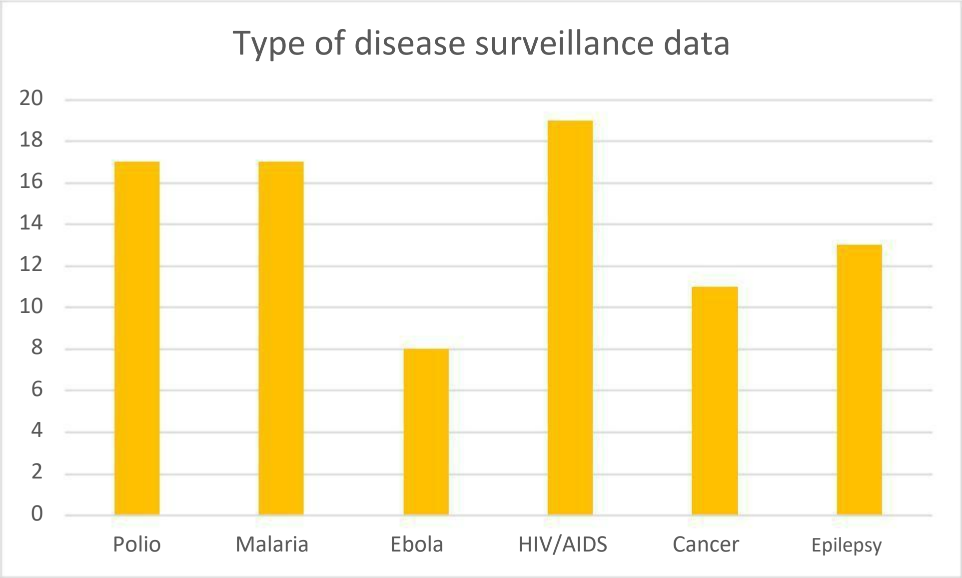


Fig 5.55: Types of disease surveillance

5.4.7.8 Duration to receive the information from other public hospitals

Fig 5.56 portrays a graphical presentation of the time frame taken to accessing disease surveillance data. The highest responses were obtained from 52% of the respondents who indicated that it took a day and 1 to 5 weeks each for them to receive information from other public hospitals. The observations were then followed by 48% of the who indicated that it took them 1-5 weeks, while 14% had indicated that it only takes them 5-10 weeks to access the information from other public hospitals.

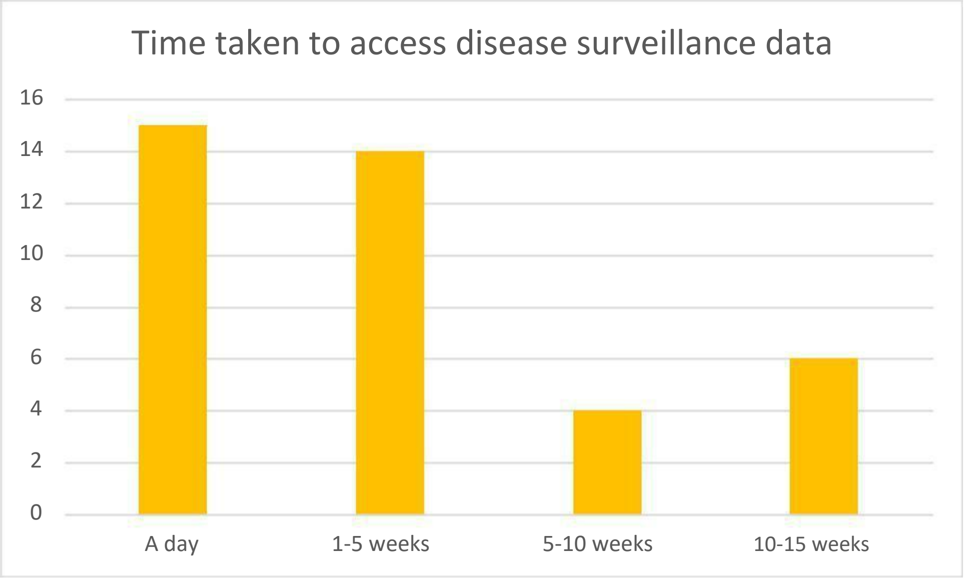


Fig 5.56 Duration to access disease surveillance data

5.4.8 Zambezi Region

This section looks at statistics according to gender and age.

5.4.8.1. Gender

Of the 52 respondents from Zambezi Region understudy, 52% (n=27) were male respondents, while 48% (n=25) were female respondents as shown in fig 5.57 below

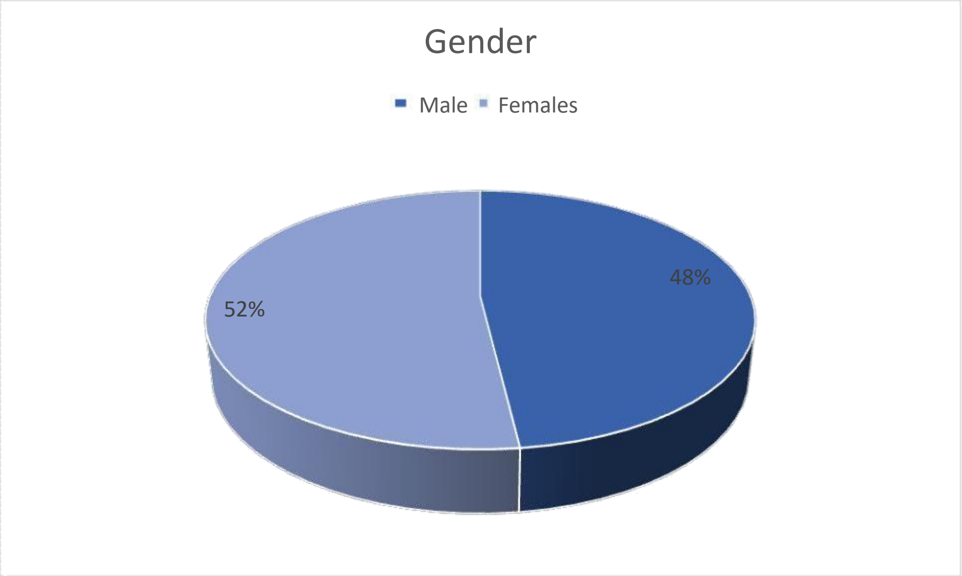


Fig 5.57: Gender

5.4.7.2 Age group

Results in fig 5.58 shows that 35% of the participants in the age group 18-25 years. The observation was then followed by 31% of the participants whom were in the age group 26-35 years, while the age group of greater than 45 years was having 15% of the total representation in the region.

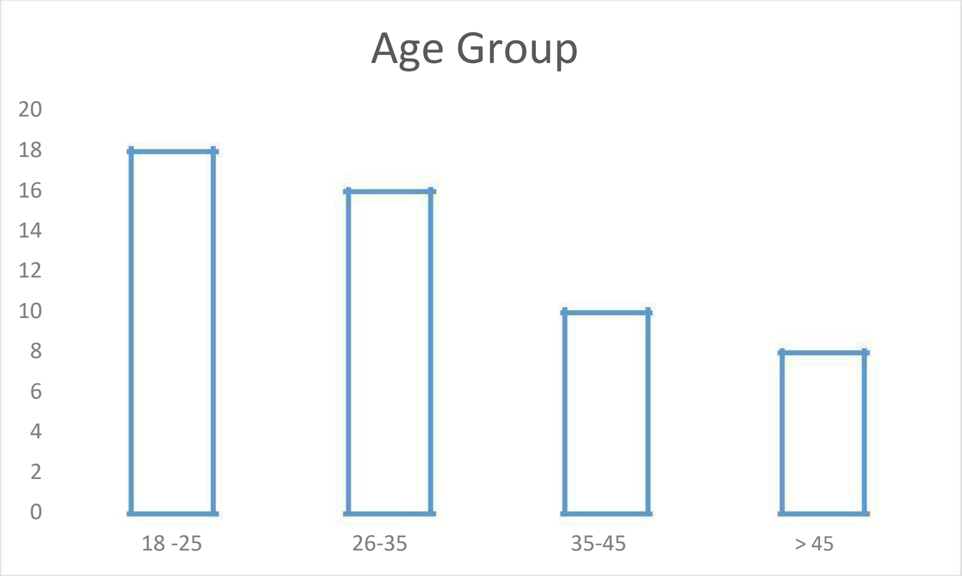


Fig 5.58: Age Group

5.4.8.3 Ways used to exchange disease surveillance data with other hospitals

Fig 5.59 below indicates that 60% of the participants were using health programs to exchange disease surveillance data with other hospitals. The observation was then followed by those who indicated staffs and as they have 52% of the respondents. However, 6% of the respondents were not sure of the ways in which they exchange disease surveillance data with others.

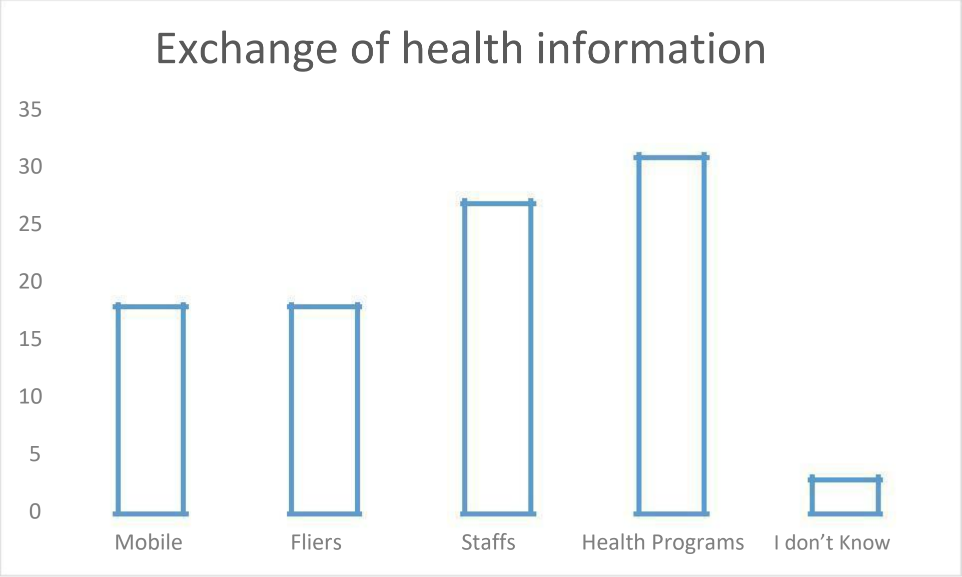


Fig 5.59 Exchanging of health information

5.4.8.4 Accessing disease surveillance data from another public hospitals in Namibia

As shown in fig 5.60, 62% of the respondents had indicated that they access disease surveillance data from another public hospitals in Namibia through visiting hospitals or clinics. The observation was then followed by 46% who indicated mobile phones, while the least responds were obtained from 29% of the respondents who had indicated fliers.

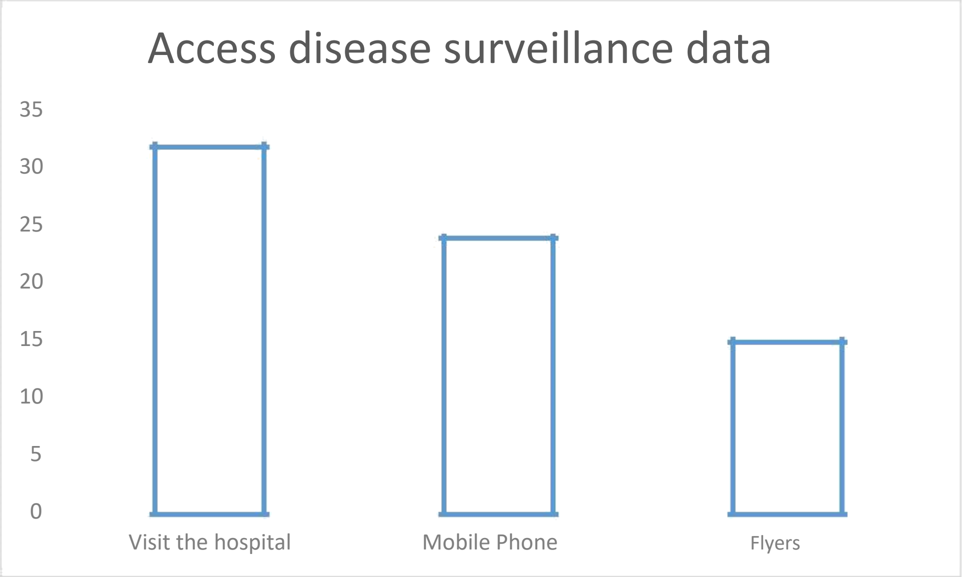


Fig 5.62 Exchanging of health information

5.4.8.5. Type of disease surveillance data exchanged with other public hospitals

When asked about type of disease surveillance data exchange with other public hospitals, 63% of the respondents had indicated that they exchange campaign related data with other public hospitals, while 37% and indicated that exchange their health record data as shown in fig 5.63 below.

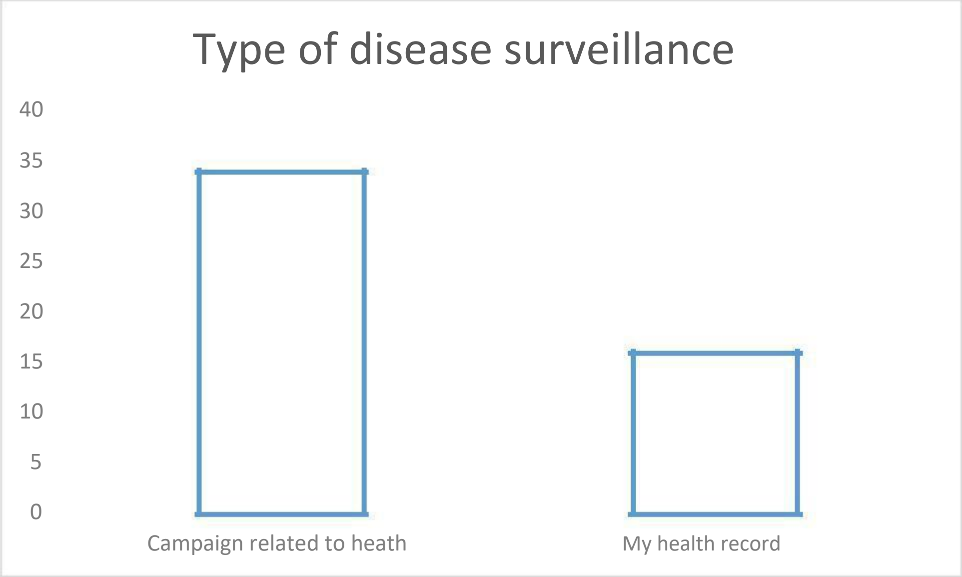


Fig 5.63 Types of disease surveillance data exchanged

5.4.8.6 Preferred ways of receiving disease surveillance data

Fig 5.64 present preferred ways of receiving disease surveillance data by the respondents. The figure shows that 65% of the respondents prefers visiting hospital, followed by 40% of the respondents who preferred mobile phones while the least response was observed from 25% of the sample understudy in the region who prefers to receive through fliers.

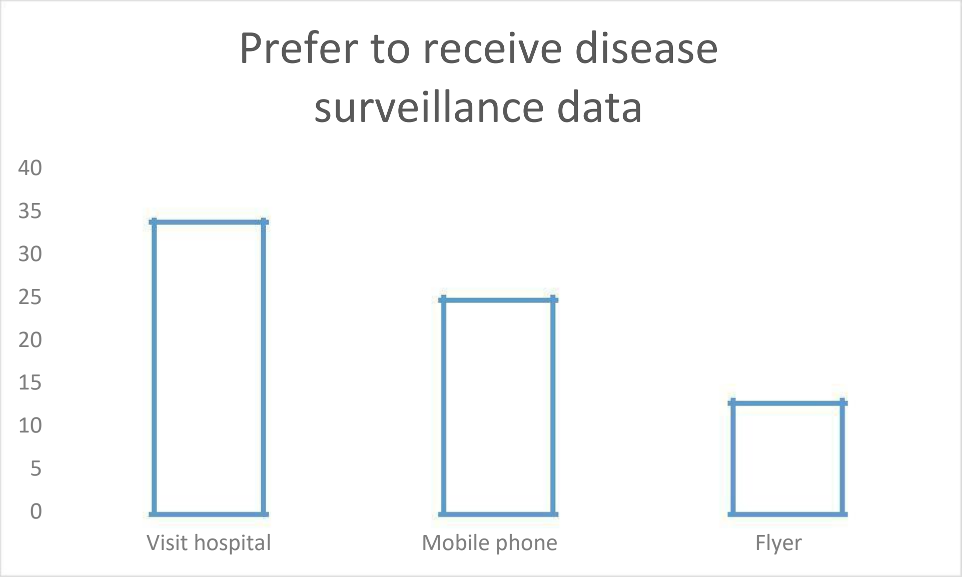


Fig 5.64: Preferred ways of receiving disease surveillance data

5.4.8.7 Types of disease surveillance data would you want to receive from other public hospitals

Fig 5.65 shows that 65% of the respondents want to receive Cancer information from other public hospitals. The observation was then followed by HIV/AIDS and Malaria who had each 63% of the sample understudy. However, the least observation was obtained from 46% of the respondents who indicated that want to receive Ebola information.

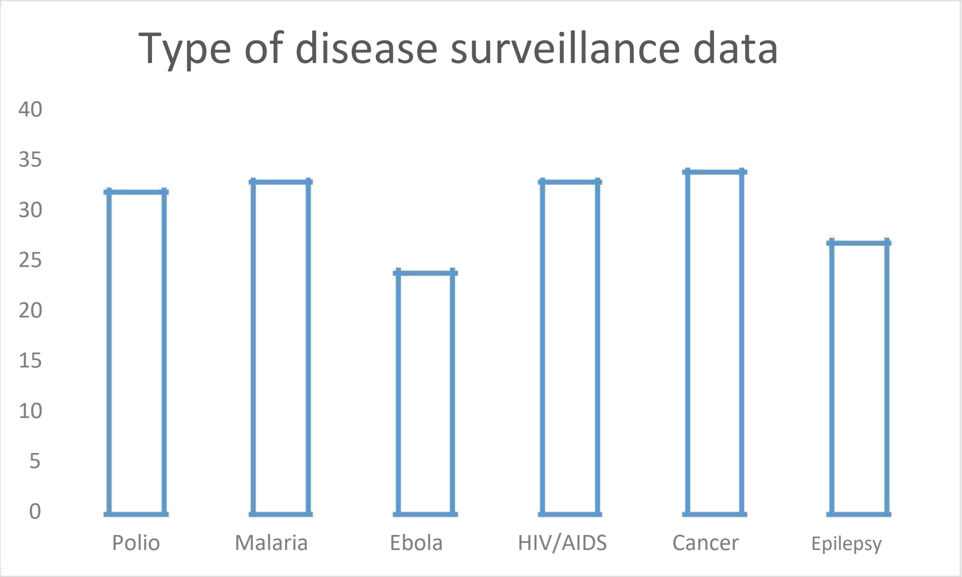


Fig 5.65: Types of disease surveillance

5.4.8.8 Duration to receive the information from other public hospitals

Fig 5.66 portrays a graphical presentation of the time frame taken to accessing disease surveillance data. The highest responses were obtained from 54% of the respondents who indicated that it took a day and 1 to 5 weeks each for them to receive information from other public hospitals. The observations were then followed by 27% of the respondents in the region who had indicated that it took them a day week, while 13% had indicated that it only takes them 5-10 weeks to access the information from other public hospitals.

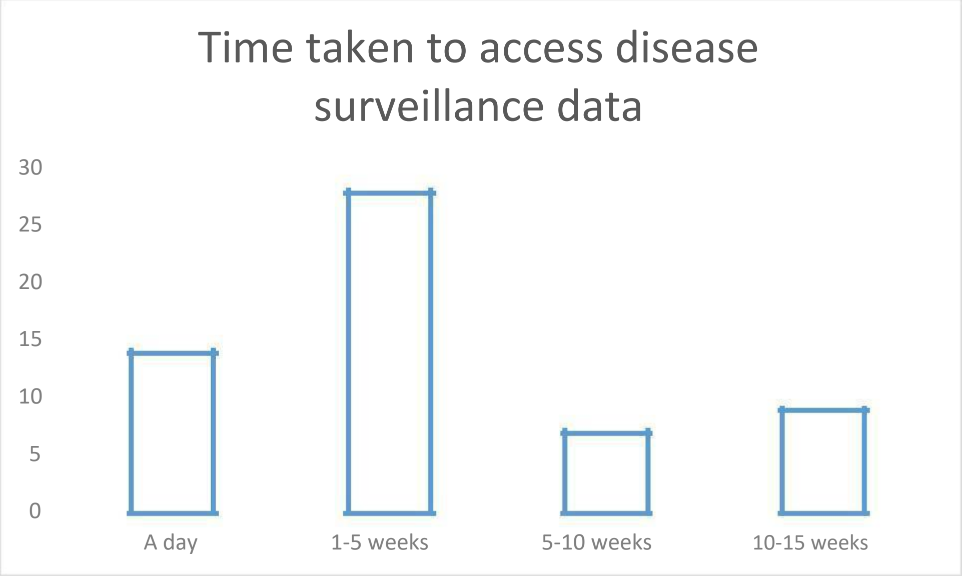


Fig 5.66 Duration to access disease surveillance data

5.4.1 Erongo Region

Table 4: Erongo public hospitals response rate

Questions	**Response rate**	**Number of Erongo participants**
As public hospital, how do you exchange disease surveillance data with other hospitals?	The participants indicated that the current methods used to communicate and exchange disease surveillance data is a manual paper-based system which is time consuming.	**30**
How do you access disease surveillance data from other hospitals and for how long?	The participants indicated that each hospital has truck drivers who transport manual paper-based documents from one hospital to the other.	**30**
What is the type of disease surveillance data from other public hospitals in Namibia?	The participants indicated that the type of disease surveillance exchanged and communicated between hospitals is in a form of Sentinel Surveillance, and Accelerated Disease Control - National Active	**30**

	and National Passive.	
How would you prefer to receive disease surveillance data from other public hospitals?	The participants indicated that they prefer to receive disease surveillance data through an integrated health information system that can aggregate data from different public hospitals.	**30**

Table 4 above shows that, Erongo region had 30 participants who responded on how public hospitals in Namibia can exchange and communicate health related information with other hospitals. Participants had also respondent the way in which they access healthcare information from other public hospitals in Namibia as well as the manner in which they prefer to receive it.

Table 5: Age group public hospital response rate

AGE GROUP	Frequency	Participants	Cumulative Percent
18-25	25.8	8	25.8
26-35	77.4	16	51.6
36-45	83.9	2	6.5
Above 45	100.0	4	16.1
Total	**100.0**	**30**	**100.0**

Results in table 5 shows that 51.6% of the participants in the age group 26-35 they exchanged disease surveillance information through a manual process which includes telephone, email, circular, and sending individuals by car to deliver disease surveillance data to each region. The observation was then followed by 25.8% of the participants in the age group 18-25, while those whose who were above 45 were only constituting 16.1% of the motion. The cumulative percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper-based systems which are not efficient and effective. Results from the respondents also indicates that each hospital has a driver who transports disease surveillance information from one hospital to the other and from the regional level to national level in the form of manual paper-based systems. Apart from this, it had been revealed that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, and accelerated disease control - national active and national passive. The MoHSS was regarded to be a custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 6: How participants prefer to exchange disease surveillance information

AGE GROUP	Frequency	Participants	Cumulative Percent	Preference of accessing disease surveillance data
18-25	29	7.5	95.5	Through mobile phone
26-35	2	7.5	4.5	Computer
36-45	31	7.5	0	Smartphone
Above 45	18	7.5	0	Mobile devices
Total	**49**	**30**	**100.0**	

Table 6, above indicates that only 49 participants were willing to access, communicate and exchange disease surveillance information through mobile devices. Of the 49 participants, 95 had indicated that they are willing to make use of cell phones, while 4.5% prefers computers. The cumulative percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is manual paper-based systems which are not efficient and effective. Results from the respondents indicates that each hospital has a driver who transports disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. Additionally, data from respondents reveals that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, and Accelerated Disease Control - national active and national passive. This implies that MoHSS as a custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 7: How participants prefer to receive disease surveillance information

Age group	**Frequency**	**Percent**	**Cumulative percent**	Preference of accessing disease surveillance data
18-25	17	34.7	25	Laptops
26-35	13	26.5	25	Computer
36-45	1	2.0	25	Smartphone
Above 45	31	63.3	**25**	Mobile device
	62	100.0	**100**	

Table 7 indicates that 31 participants prefers to access data using mobile devices. The decision was then followed by 17 respondents who had indicated laptops. The table further reveals that all (100%) respondents in this category prefers to use modern technology as a means of communicating and exchanging disease surveillance data information from one hospital to the other hospital.

Table 8: Type of disease surveillance information respondents want to receive

Cancer	Age group	Frequency	Percent	Cumulative percent
	18-25	28	57.1	25
	26-35	3	6.1	25
	36-45	31	63.3	25
	Above 45	18	36.7	**25**
Total		**49**	100.0	**100**

As shown in table 8 above, 63.3% of the respondents who indicated that they would need to receive cancer information and disease surveillance data are in the age group of 36-45. The observation is then followed by 57.1% who are in the age group of 18-25, while the least response was obtained from 6.1% in the age group of 25-35years

Table 9: Duration of accessing disease surveillance data from other public hospitals

Number of participants	Age group	Frequency	Percent	Cumulative percent	Periods it takes to access disease surveillance data response rate
30 participants	**18-25**	5	10.2	25	A month on average
	26-35	26	53.1	25	A week on average
	36-45	31	63.3	25	A month on average
	Above 45	18	36.7	**25**	A week on average
Total		**49**	100.0	**100**	

63.3 % of the respondents in the age group of 36-45 had indicated that it takes on average a month for CDC regional offices to access disease surveillance information from the regions after an incidence has been reported. The current method of communicating disease surveillance information is not appropriate as it does support real-time access information from regional offices across the country for prompt decision making. The cumulative percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is manual paper-based systems which are not efficient and effective. Each hospital transports disease surveillance information from one hospital to the other and from the regional level to national level in the form of manual paper-based systems. Additionally, it had been indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, and accelerated disease control - national active and national passive. As a custodian, the MoHSS should facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different HIS.

Gender

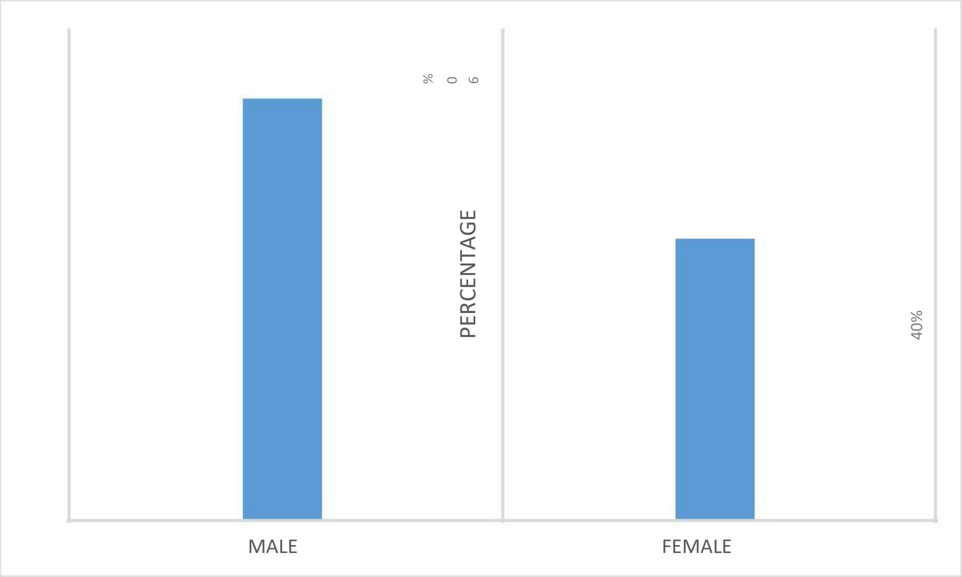


Figure 1: Gender response rate

Figure 1 shows that 60% of the respondents are male, while 40% are female respondents.

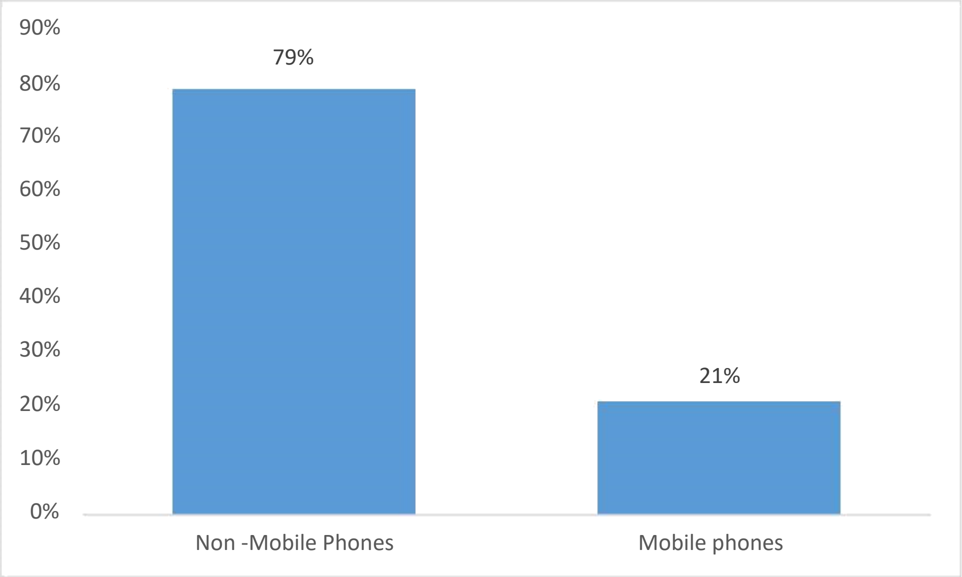


Figure 2: Exchange disease surveillance information

Figure 2 above shows that majority (79%) of the respondents receive disease surveillance data through mobile phone in public hospitals while 21% participants have indicated the use of mobile phones.

5.2.2 Karas region public hospitals response rate

Table 10: Kara's public hospitals response rate

Questions	**Response rate**	**Number of Karas participants**
As a public hospital, how do you exchange disease surveillance data with other hospitals?	The participants indicated that the current methods used to exchange disease surveillance data with other hospitals is a manual paper based system which is efficient and effective when exchange disease surveillance data within hospitals.	**20**
How do you access disease surveillance data from other hospitals in Namibia and for how long?	The participants indicated that each public hospitals have a drive that transport manual paper based from the regional level to national level in Windhoek.	**20**
What type of disease surveillance data from other public hospitals in Namibia?	The participants indicated that the type of surveillance data exchanged and communicated from regional level to national level are sentinel surveillance, accelerated disease control -national active and national passive.	**20**
How would you	The participants indicated that that they prefer an integrated health information	**20**

prefer to receive disease surveillance data from other public hospitals?	systems that can aggregate disease surveillance data from all the public hospitals.	

Table 10 above indicates responses from 20 participants in Karas region. The respondents were made up of 9 males and 11 females. Results from the respondents indicates that a manual system is the one which is used to exchange and communicate data, although the respondents regard it to be inappropriate time consuming, hence ineffective. Apart from this, most of the respondents had indicated that they prefer to access and communicate disease surveillance data through an integrated health system as it has the capacity to aggregate disease surveillance data from one hospital and to another hospital.

Table 11: Gender response rate from Karas region

Gender	Frequency	Percent	Cumulative percent
MALE	9	45.0	45.0
FEMALE	11	55.0	100.0
Total	20	100.0	

Table 11 indicates that the study population was constituting 55% male respondents and 45% female respondents

Table 12: Age group response rate

AGE GROUP	Frequency	Percent	Cumulative Percent
18-25	6	30.0	30.0
26-35	9	45.0	75.0
36-45	4	20.0	95.0
Above 45	1	5.0	100.0
Total	20	100.0	100.0

As shown in Table 12 above, the highest response was obtained from 45% of the respondents were in age group of 26-35. This was then followed by 30% of the respondents from the age group of 18-25, while the least representation was obtained from those above 45 years as they were only occupying 5% of the proportion. The participants indicated that the current methods of exchanging and communicating disease surveillance data are by telephone, email, circular.

The participants' age group above 45 years which constitutes 5% of the participants indicated that the method of exchanging and communicating disease surveillance data is a manual system which is not appropriate. The percentages of the participants were 40%. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 13: Exchange disease surveillance information

AGE GROUP	Frequency	Participants	Cumulative Percent	Preference of accessing disease surveillance data
18-25	11	5	95.5	Through mobile phone
26-35	9	5	4.5	Through mobile phone
36-45	20	5	0	Through mobile phone
Above 45	11	5	0	Through mobile phone
Total	**49**	**20**	**100.0**	Through mobile phone

Table 13, indicates that 20 participants in all age groups preferred receiving disease surveillance data through mobile phone. The percentages of the participants were 40%. The cumulative percent, percent and frequency in each age group means **the** participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated d*i*sease control - national active and national Passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 14: Accessing disease surveillance information

AGE GROUP	Frequency	Percent	Cumulative Percent	Methods of accessing disease surveillance data
18-25	6	60.0	30.0	Visit the hospital or Clinic
26-35	9	5.0	75.0	Through mobile phone
36-45	4	35.0	95.0	Visit the hospital or Clinic
Above 45	1	60.0	100.0	Through mobile phone
Total	20	100.0		

From table 14, 20 participants indicated that they preferred to receive disease surveillance data through mobile phones, laptops, desktop computers, and tablets but not in the traditional methods such as circulars, telephones, and email. The participants who stated that they would want to access and communicate disease surveillance data through mobile phone were 60%. The participants who wanted to receive disease surveillance data through visiting the hospitals or clinics were 5%. Overall, this may mean that majority of the participants want to receive disease surveillance data through mobile phone. The percentages of the participants were 40%. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated

surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 15: Type of disease surveillance information

Types of surveillances	Frequency	Percent	Cumulative Percent
Sentinel Surveillance	9	45.0	45.0
National Passive	11	55.0	100.0
Total	20	100.0	

From Table 15, the type of information the participants want is disease surveillance data which is currently done manual and the percentages of participants were 45%. The percentages of the participants were 40%. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 16: Preference of receiving disease surveillance information

Type of disease surveillance preference	Frequency	Percent	Cumulative Percent
Mobile phones	8	40.0	40.0

Computers	12	60.0	100.0
Total	20	100.0	

From table 16, the participants indicated that they prefer to receive disease surveillance information from other hospitals through modern technology such as using tablet, laptop, desktop computer, mobile phone etc. The percentages of the participants were 40%. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 17: Type of disease surveillance data respondents want to receive

Type of disease surveillance data	Frequency	Percent	Cumulative Percent
HIV/AIDS information	**18**	90.0	90.0
Cancer information	**1**	5.0	95.0
	1	5.0	100.0
Total	**20**	100.0	90.0

From Table 17, part from disease surveillance data, the participants also indicated that the type of healthcare information they want to receive is HIV/AIDS information and also cancer information which was represented by 5%. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 18: Duration of accessing disease surveillance data

Period it take to receive disease surveillance data	Frequency	Percent	Cumulative Percent
A month on average	9	45.0	45.0
Within a day	11	55.0	100.0
Total	20	100.0	

From Table 18, most of the participants indicated that it took time, an average of about a month when one hospital or health institutions in Namibia would want to receive and access information. The 45% participants indicated that it took time. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

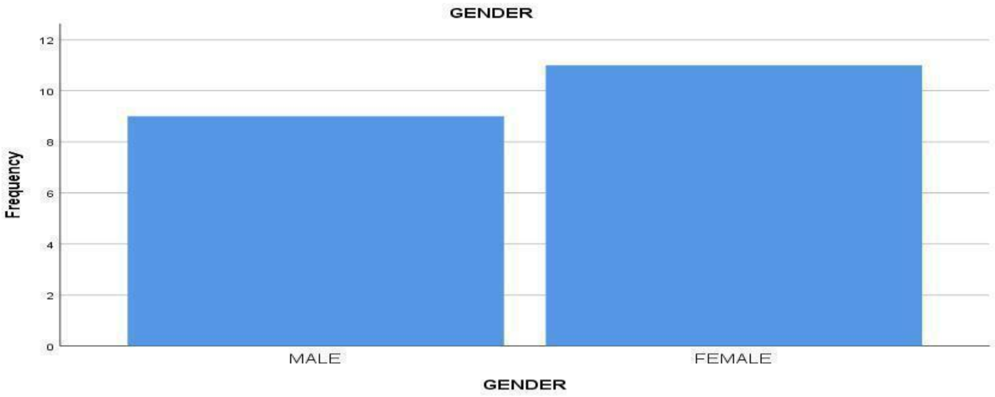


Figure 3: Gender response rate

In Figure 3, the bar graph represents a number of males and females who participated in the study, specifically from the Karas region on how they exchange, access, receive and communicate with other public hospitals or with other public health institutions. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

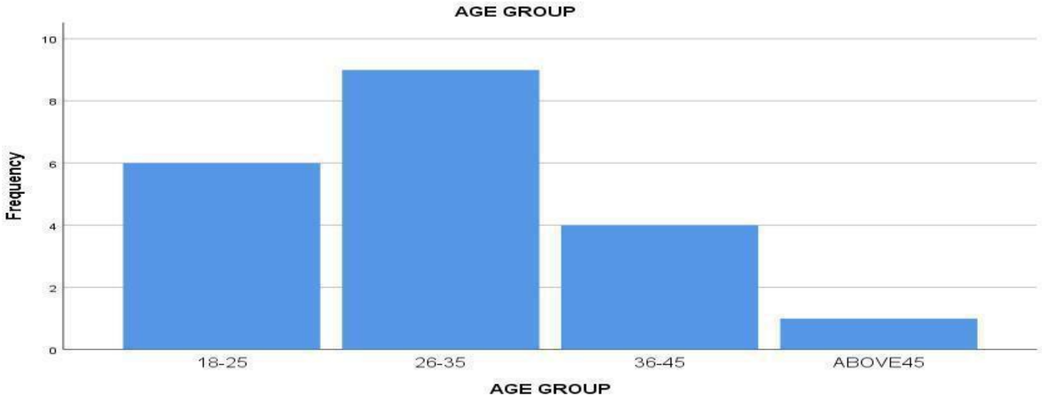


Figure 4: Age group response rate

From Figure 4, the participants were also represented by age group. Those between 18-25 years had a frequency of 6. The age group between 26-35 years had a frequency of 8.5. The age group between 36-45 years, participants had a frequency of 4. The above 45 years represent a frequency of 1.1 The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

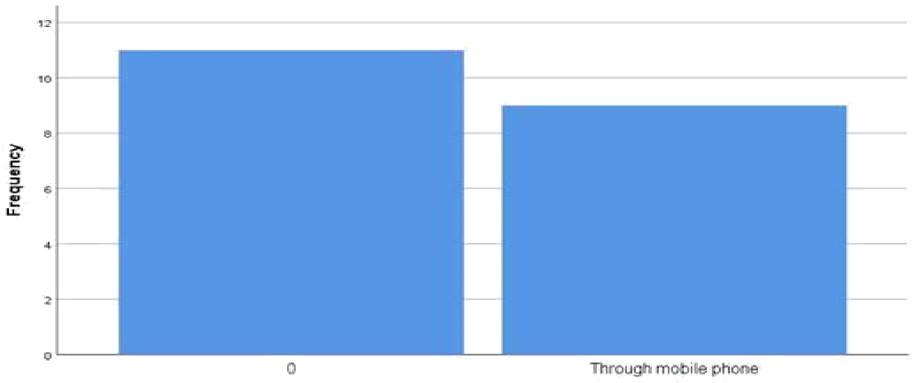


Figure 5: Exchange disease surveillance data response rate

The bar chart in Figure 5 represents the number of participants who would want to access and communicate disease surveillance information through mobile phone which is represented by a frequency of 8.5. The zero on the graph represent the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

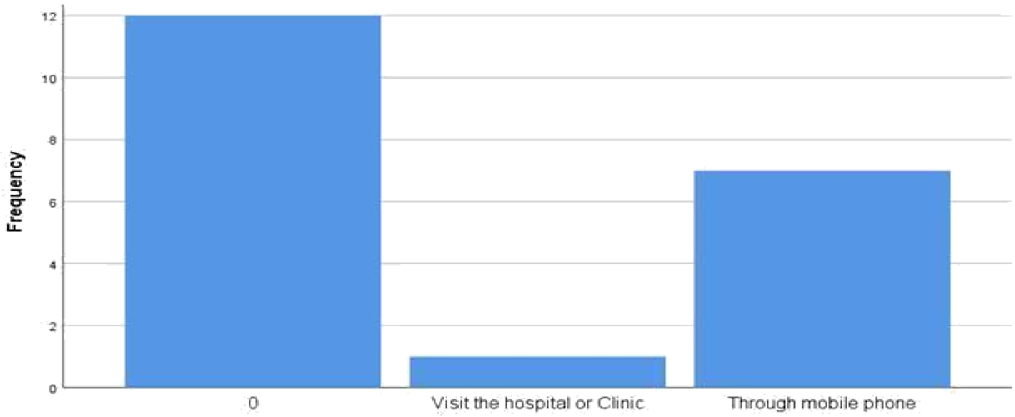


Figure 6: Accessing disease surveillance data

The bar chart in Figure 6 indicates how public hospitals in Namibia access and communicate disease surveillance data through mobile phones and also through visiting hospitals or clinics. The zero on the graph represent the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

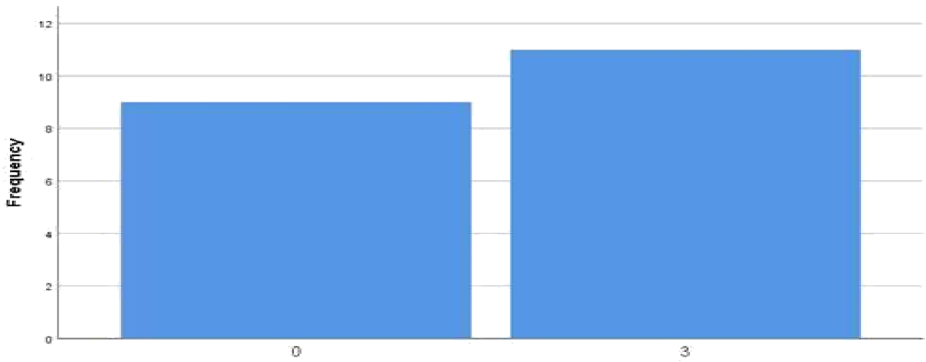


Figure 7: Accessing disease surveillance data

The bar graph in figure 11 represents participants who indicated that the type of disease surveillance data is currently received through a manual system there is no system or framework to aggregate data. The zero and 3 on the graph represent the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

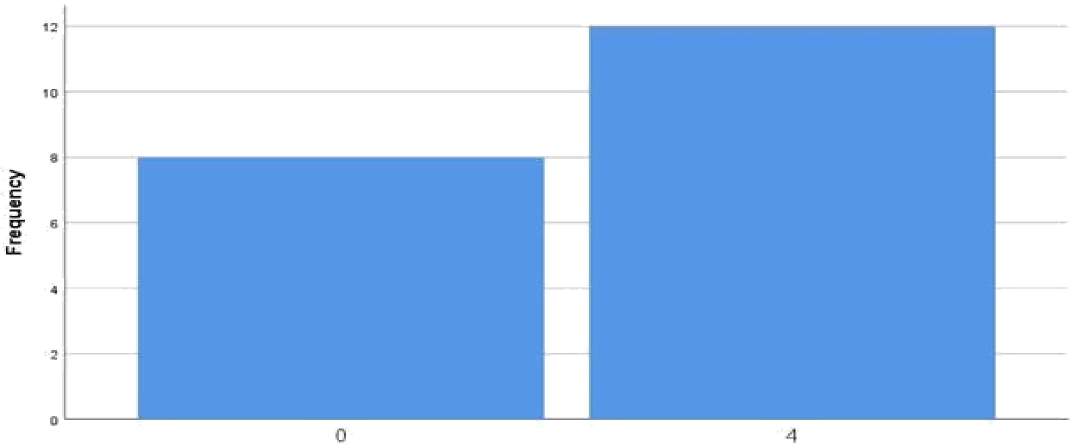


Figure 8: Preference to receive disease surveillance data

In Figure 8, the participants indicated that they preferred receiving disease surveillance data through mobile devices, laptop, desktop computer, tablet etc. The zero and 4 on the graph represent the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

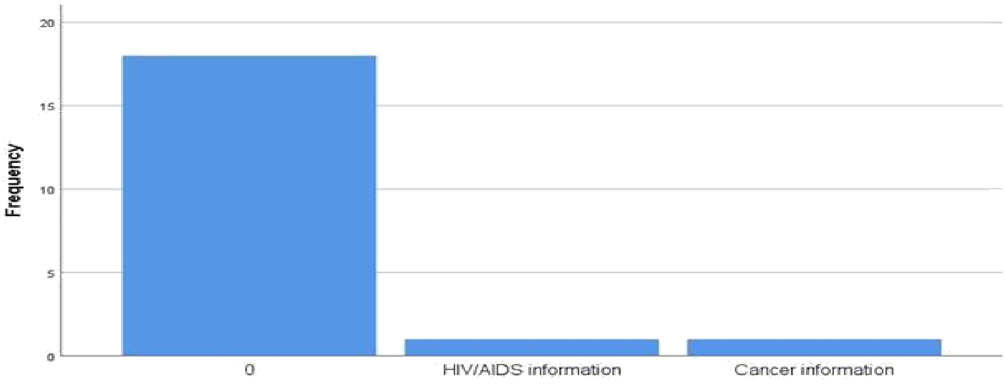


Figure 9: Type of disease surveillance respondents want to receive

In Figure 13, the participants indicated that the type of healthcare information is disease surveillance data in addition HIV/AIDS and cancer information. The zero, HIV/AIDS and cancer information represent the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems on exchange information such as HIV/AIDS information and cancer information. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

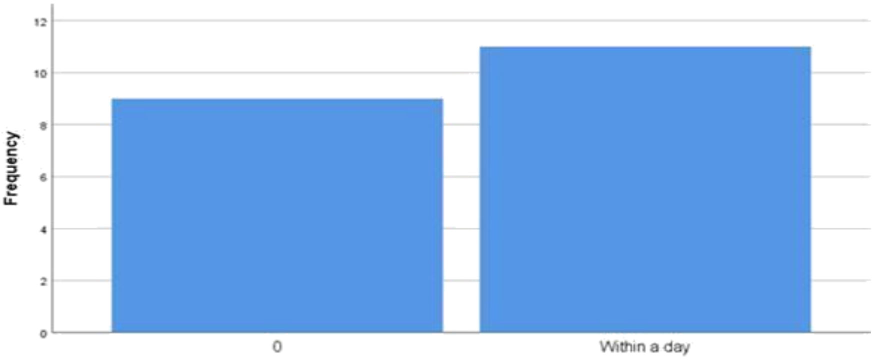


Figure 10: Duration of accessing disease surveillance data

In Figure 10, the larger portion of participants indicated that it did not take within a day to receive disease surveillance data from another public hospital or from other health institutions in Namibia due to the fact that it takes time about a month on average. The 0 and within a day on the bar graph represents the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

5.2.3 Khomas region public hospitals response rate

Table 19: Khomas region public hospitals response rate

Questions	Response rate	Number of Khomas participants
As public hospital, how do you exchange disease surveillance data within other hospitals?	The participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective.	**35**
How do you access disease surveillance data from other hospitals in Namibia and for how long?	The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems.	**35**
What type of disease surveillance data from other public hospitals in Namibia?	The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are	**35**

	Sentinel Surveillance, Accelerated Disease Control - National Active and National Passive.	
How would you prefer to receive disease surveillance data from other public hospitals?	The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.	**35**

In Khomas region a total of 35 participants, participated in the study of which male were 16, females were 19. In Khomas region the participants indicated that the current methods used to exchange and communicate disease surveillance data from regional to national level is a manual paper based system which not efficient and effective communication. The majority of the participants indicated that they prefer to access and communicate disease surveillance data through an integrated health system that can aggregate disease surveillance data from one hospital and to another hospital.

Table 20: Gender response rate

Gender	Frequency	Percent	Cumulative Percent
MALE	16	32.0	45.7
FEMALE	19	38.0	54.3
Total	35	70.0	**100.0**

From Table 20, the participants include both male and female. The numbers of males were 16 with a percentage of 45.7% and the number of females was 19 with the percentage of 54.3%. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country

Table 21: Age group response rate

AGE GROUP	Frequency	Percent	Cumulative Percent
18-25	6	12.0	17.1
26-35	13	26.0	54.3
36-45	5	10.0	68.6
ABOVE45	11	22.0	100.0
Total	35	70.0	

In Table 21, the participants aged between 18-25 years were 6, those aged between 26-36 years were 13, between 36-45 years were 5 and those aged above 45 years were 11. The percentages of ages between 18-25 years was 17%, aged between 26-35 years was 37.1%, aged between 36-45 years was 14.3% and aged above 45 years was 31.4%.

Table 22: Exchange disease surveillance data

Methods of exchanging disease surveillance data	Frequency	Percent	Cumulative Percent
Manual paper based systems	29	58.0	82.9
Through mobile phone	6	12.0	100.0
Total	35	70.0	100.0

In Table 22, the participants indicated that they exchange and communicate disease surveillance data through a manual system which takes time and causes delays when one public hospital or public institution wants to access or communicate such information to another hospital with a total frequency of 35%. The participants indicated that 82.9% of the current system used a manual system which is not efficient and effective in case of emergency. At the same time, they also indicated that they preferred to receive disease surveillance data through mobile phone which is represented on the table as 100%.

Table 23: Preference to receive disease surveillance data

Types of receive disease surveillance data	Frequency	Percent	Cumulative Percent
Manual paper based systems	16	32.0	45.7
Mobile phone	18	36.0	97.1
Flyers	1	2.0	100.0
Total	35	70.0	

In Table 23, the participants indicated that they preferred to receive and exchange disease surveillance data through the use of mobile phone. 45.7% of participants indicated that they prefer exchanging, communicating and receiving disease surveillance data through modern technology. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 24: Type of disease surveillance data respondents want to receive

Types of disease surveillance data	Frequency	Percent	Cumulative Percent
Cancer information	3	6.0	100.0
Total	35	70.0	

In Table 24, in addition to disease surveillance data, the participants also indicated that the type of healthcare they would want to communicate, exchange, and receive was cancer information which was represented by 100% as cumulative percent on the table. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 25: Duration of receiving disease surveillance data

Period it takes to receive disease surveillance data	Frequency	Percent	Cumulative Percent
A month on average	5	10.0	14.3
Within a day	29	58.0	97.1
Between 1-5 weeks	1	2.0	100.0
Total	35	70.0	100.0

In Table 25, the participants indicated that it takes about 29 days for one public hospital to receive disease surveillance data from other public hospitals and also it takes between 1-5 weeks which is represented by 2.95. 82.9% of participants indicated that it takes long in order for them to access disease surveillance data from another public health institution. The cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

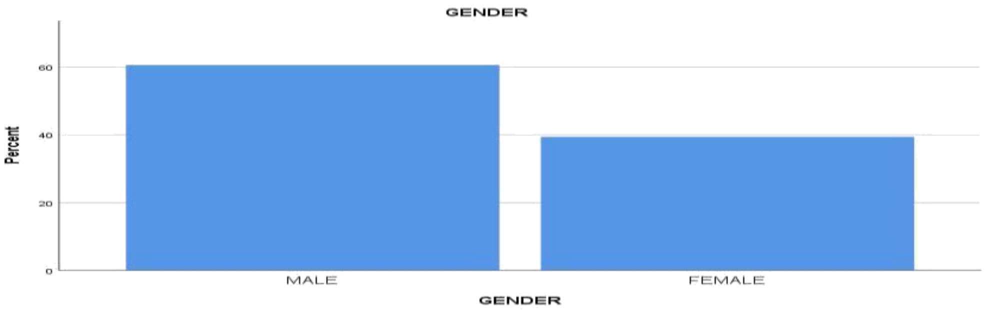


Figure 11: Gender response rate on a bar chart

The bar chart in Figure 14 represents the numbers of males and females who were engaged with male representing 60% and female 30%. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

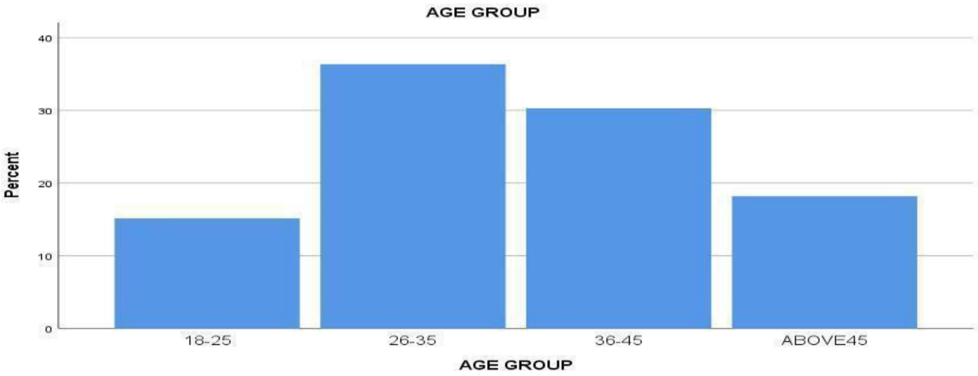


Figure 12: Age ground response rate on a bar chart

The bar chart in Figure 12 represents the age groups of the participants. The age groups on the bar chart represents the age groups of participants in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

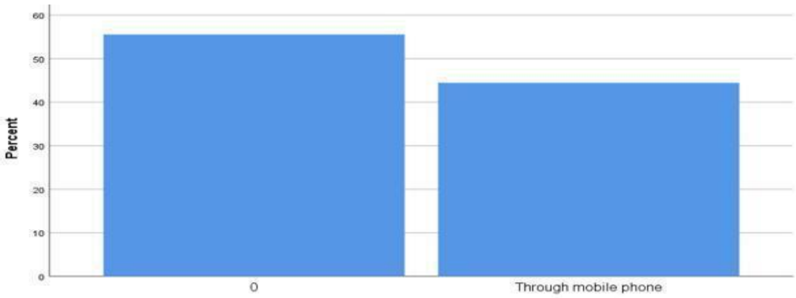


Figure 13: Exchange disease surveillance data

The bar chart in Figure 13 represents the indication of participants who were engaged which symbolises how public hospitals in Namibia exchange, communicate disease surveillance data from other public hospitals. The zero represents 55% of participants who indicated that they receive and exchange disease surveillance data through a manual paper based systems and 45% indicated that mobile phone are not used at the moment as means of exchanging and communicating disease surveillance among public hospitals in Namibia.

This percentages means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease Control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

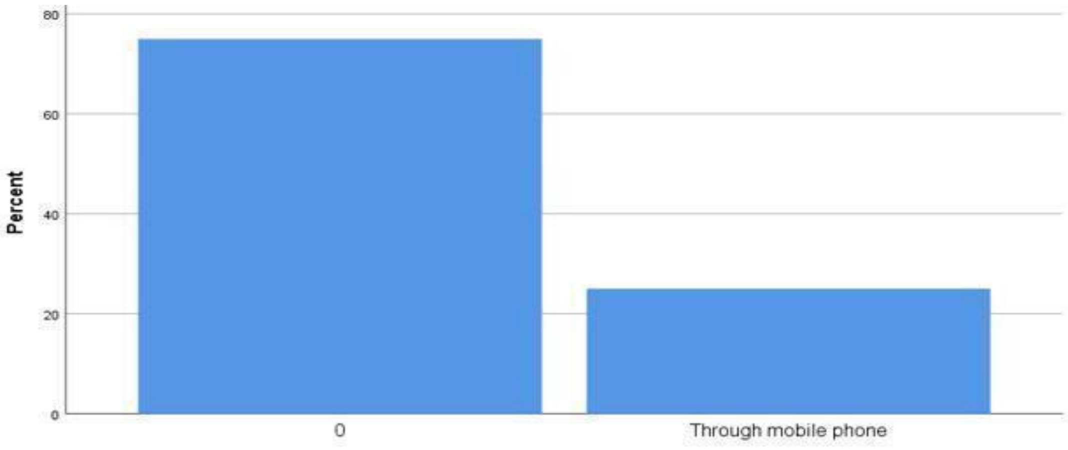


Figure 14: Accessing disease surveillance data

The bar chart in Figure 14 shows the current methods to access and communicate disease surveillance data to other public hospitals in Namibia which is done telephonically, email, and circular or through traditional methods of communication and exchange. The zero on the bar graph represents 70% of participants' access manual paper based system and 21% access disease surveillance through mobile phone.

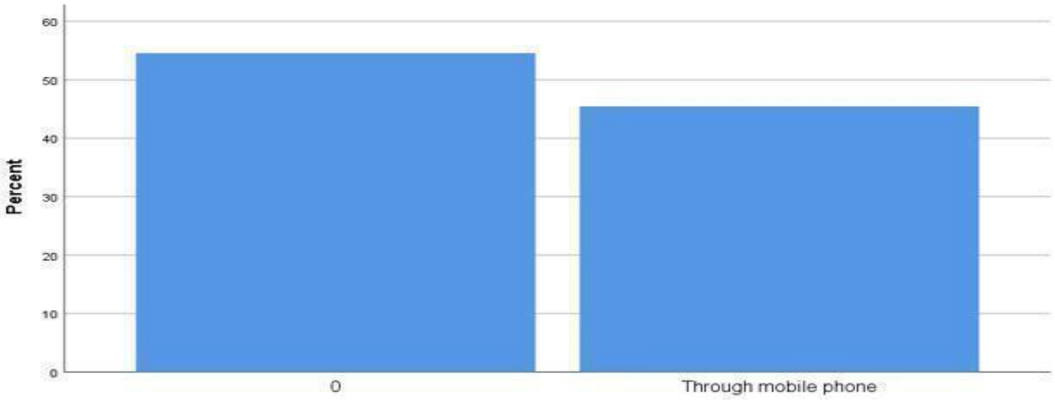


Figure 15: Type of disease surveillance

The graph in Figure 15 represents the type of healthcare information public hospitals in Namibia exchange with other hospitals which is cancer information in addition to disease surveillance information. The zero on the bar graph represents 57% of public hospital participants indicated that they exchange and access disease surveillance data through manual paper based systems from regional level to national level. Only 45% participants who leave in urban area have access to mobile phone even though they do not exchange and communicate disease surveillance among hospitals in Namibia.

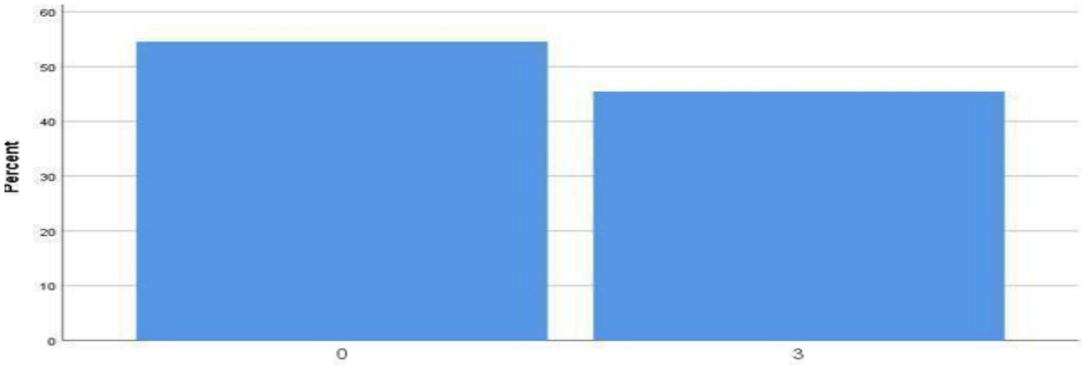


Figure 16: Preference to receive disease surveillance data

The graph in Figure 16 shows the preference of the participants on how they want to access, communicate and exchange disease surveillance data with other public hospitals. The zero on the bar graph represents 55% of participants who indicated that they prefer an integrated health information system that can aggregate data from different hospitals in Namibia. The 3 on the bar graph represent 45% of participants who indicated that they prefer to receive disease surveillance data through mobile devices.

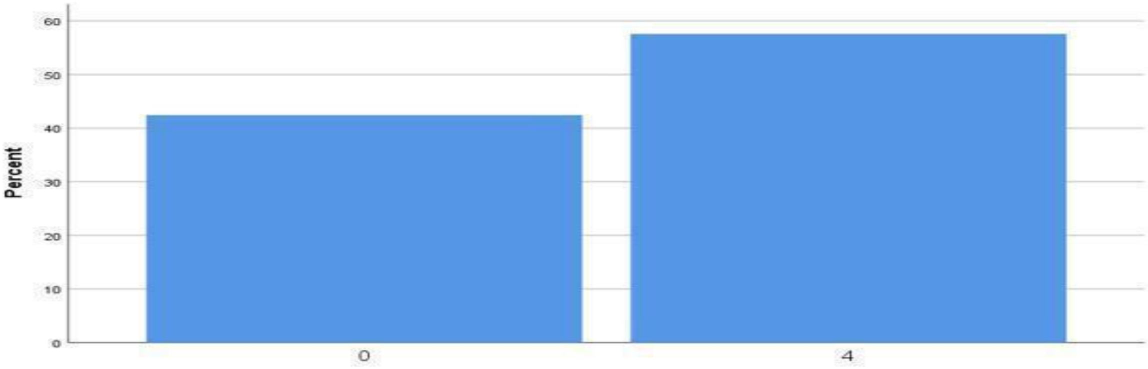


Figure 17: Type of disease surveillance data respondents want to receive

The graph in Figure 17 shows what type of healthcare information public hospitals in Namibia would want to receive from other public hospitals which include disease surveillance data and specifically cancer information and HIV/AIDS and malaria as these are the local diseases that affect most people in Namibia. The zero on the graph represent 42% of participants who indicated that they want to access disease surveillance data through mobile phones and 4 on the bar graph represents 53% of participants who indicated that they want to receive disease surveillance data through an integrated health information system.

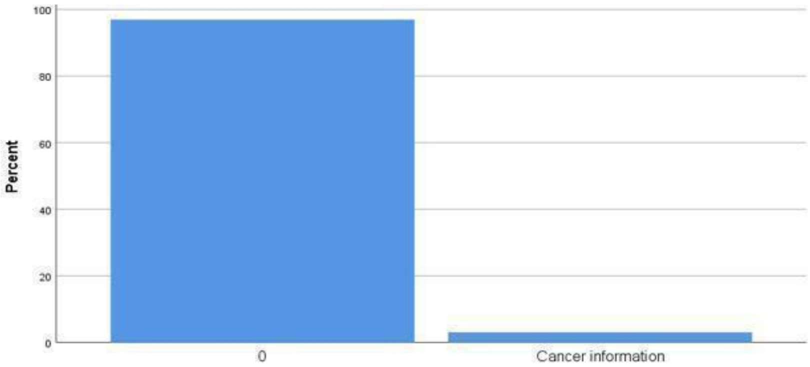


Figure 18: Duration to receive disease surveillance data

The graph represents the number of days it takes for public hospitals to access, communicate and exchange disease surveillance data from one public hospitals to another public hospital. The zero on the bar graph represent 95% of participants who indicated that it takes on average a month to receive diseases surveillance data from one hospital to the other. The bar graph indicates cancer information as 2% which represent the type of disease information exchanged between hospitals which is done through a manual paper based systems.

5.2.4 Kunene region public hospitals response rate

Table 26: Kunene public hospitals response rate

Questions	**Response rate**	**Number of Kunene participants**
As public hospital, how do you exchange disease surveillance data within other hospitals?	The participants indicated that the current methods used to exchange and communicate disease surveillance is a manual paper based system which is not appropriate when exchanging and communicating disease surveillance data between hospitals.	**33**
How do you access disease surveillance data from other hospitals in Namibia and how long?	The participants indicated that the current methods of exchanging and communicating disease surveillance data is manual paper based systems which is not efficient and effective when hospitals are exchanging data among each other.	**33**
What type of	The participants	**33**

disease surveillance data from other public hospitals in Namibia in percentage?	indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.	
How would you prefer to receive disease surveillance data from other public hospitals in percentage?	The participants indicated that they prefer to access disease surveillance data through an integrated health information systems that can aggregate data among hospitals.	**33**

From Table 26, a total of 33 participants (males and females) in Kunene region participated. Of these 32 indicated that they exchanged disease surveillance data or health related information from other hospitals through a traditional manual system. In Kunene region **th**e participants indicated that the current methods used to exchange and communicate disease surveillance data from regional to national level is a manual paper based system which not efficient and effective communication. The majority of the participants indicated that they prefer to access and communicate disease surveillance data through an integrated health system that can aggregate disease surveillance data from one hospital and to another hospital.

Table 27: Gender response rate Kunene region

GENDER	Frequency	Percent	Cumulative Percent
MALE	20	60.6	60.6
FEMALE	13	39.4	100.0
Total	33	100.0	

In table 28, the males were 20 (60.6%), while females were 13 (39.4%). These percentages mean the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 28: Age group response rate

AGE GROUP	Frequency	Percent	Cumulative Percent
18-25	5	15.2	15.2
26-35	12	36.4	51.5
36-45	10	30.3	81.8
ABOVE45	6	18.2	100.0
Total	33	100.0	

From Table 28, the age group between 18-25 years were 5 which is 15.2%; the age group between 26-35 years were 12 which is 36.4%; the age group between 36-45 years were 10 with 30.3% and the age group above 45 years were 6 with 18.2%.

Table 29: Exchange disease surveillance data

Methods of exchanging disease surveillance	Frequency	Percent	Cumulative Percent
Manual paper based systems	24	72.7	75.0
Through mobile phone	8	24.2	100.0
Total	32	97.0	

From Table 29, the participants indicated that they exchanged, communicated and received disease surveillance data through a manual system which is not appropriate in case of emergency when an incident is reported, 8 participates indicated that they preferred to access, communicate and exchange disease surveillance data through modern devices such as mobile phone. These percentages mean the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are Sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated

surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 30: Accessing disease surveillance data

Methods of accessing disease surveillance data	Frequency	Percent	Cumulative Percent
Manual disease surveillance data	18	54.5	54.5
Through mobile phone	15	45.5	100.0
Total	33	100.0	100.0

From Table 30, the majority of the participants indicated that they preferred to exchange, communicate disease surveillance data through mobile phone with 54.4%. This percentages means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 31: Type of disease surveillance data

Types of disease surveillances	Frequency	Percent	Cumulative Percent
Sentinel Surveillance	18	54.5	54.5
National Passive	15	45.5	100.0
Total	33	100.0	100.0

From Table 31, the participants also indicated that the type of healthcare information public hospital received from other public hospital is disease surveillance information and they preferred exchanging and communicating disease data through mobile phone. This percentages means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 32: Preference to receive disease surveillance data

Preference of receiving disease	Frequency	Percent	Cumulative Percent

surveillance data			
Manual paper based systems	14	42.4	42.4
Mobile phones	19	57.6	100.0
Total	33	100.0	

From Table 32, the participants indicated that they would want to exchange and communicate disease surveillance data through modern technology such cellphone, tablet, laptop, desktop computer etc. This percentages means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 33: Type of disease surveillance data respondents want to receive

Types of disease surveillance data	Frequency	Percent	Cumulative Percent
National Passive	32	97.0	97.0
Cancer information	1	3.0	100.0

Total	33	100.0	

From Table 33, the type of healthcare information in addition to disease surveillance data is national passive and cancer information participants also indicated that they preferred communicating and exchanging disease surveillance data through modern technology. This percentages means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 34: Duration to receive disease surveillance data

Periods it takes to receive disease surveillance data	Frequency	Percent	Cumulative Percent
A month on average	11	33.3	33.3
Within a day	22	66.7	100.0
Total	33	100.0	

From table 34, the participants indicated that it took time to receive, communicate and exchange disease surveillance data from another hospital which caused delays when health professionals want to make quick decisions. These percentages mean the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

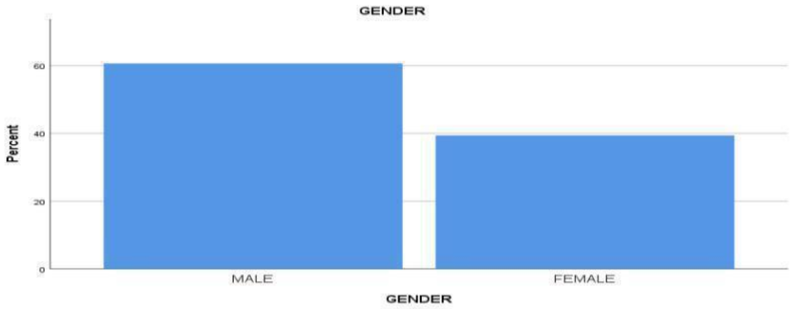


Figure 19: Gender response rate

The bar graph in Figure 19 represents both male and female in a format of percentages, male 60% and female 39%. Males were the most dominant to participate compared to females.

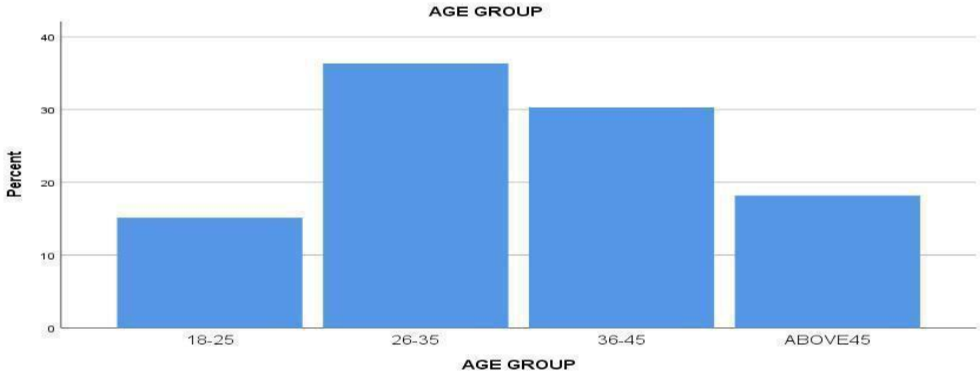


Figure 20: Age group response rate

The bar graph in Figure 20 represents age groups between 18-25 years, 26-35 years, 36-45 years and above 45 years. The percentage age between 18-25 years was 15%, age group between 26-35 years was 35%, age group between 36-45 years was 30% and above 45 years was 16%.

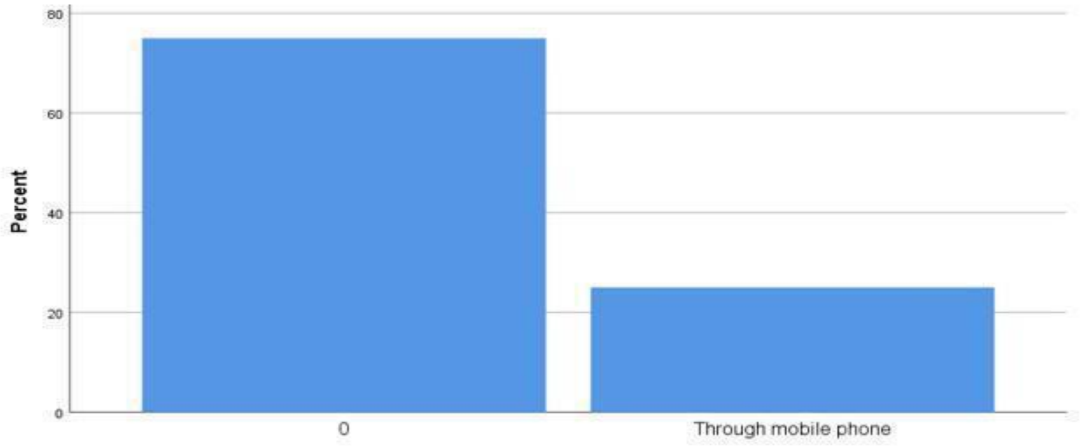


Figure 21: Exchange disease surveillance data

The bar graph in Figure 24 shows the preference of participants which indicated that they preferred to access, exchange and communicate disease surveillance data through modern technology such as mobile phone, tablet, laptop and desktop computer. The other participants indicated they would not want to access, communicate and exchange disease surveillance data from another health institution through traditional methods of communication such as circular, etc. These percentages mean the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance system that can aggregate data from different hospitals in the 14 regions of the country.

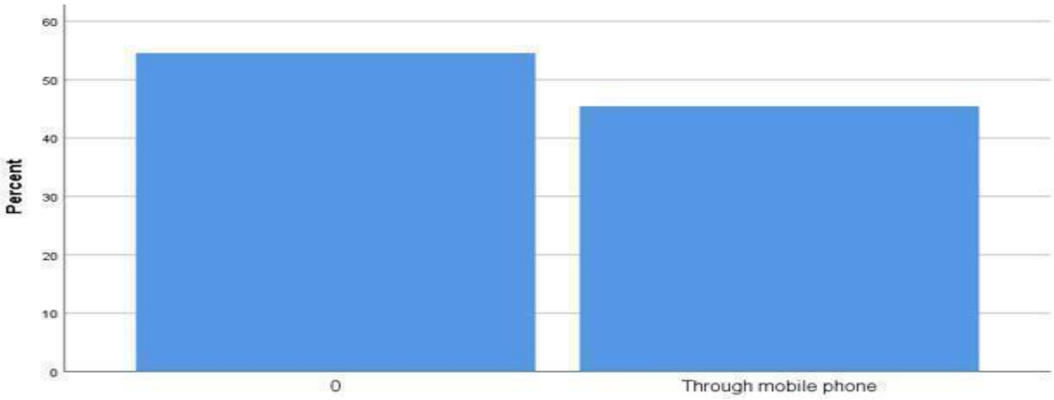


Figure 22: Accessing disease surveillance data

The participants indicated that they accessed, communicated and exchanged disease surveillance data from another hospital through a traditional method of communication which is inappropriate in case of emergency when an incidence of particular disease has been reported. The zero on the bar chart represents 55% of participants who indicated that the current methods used to access disease surveillance data is a manual paper based systems and through mobile phone on the bar chart represents 45% participants who indicated that they do not access disease surveillance data between public hospitals in Namibia and they prefer to exchange and communicate disease surveillance data to other hospitals because is fast method of communication between public hospitals in Namibia.

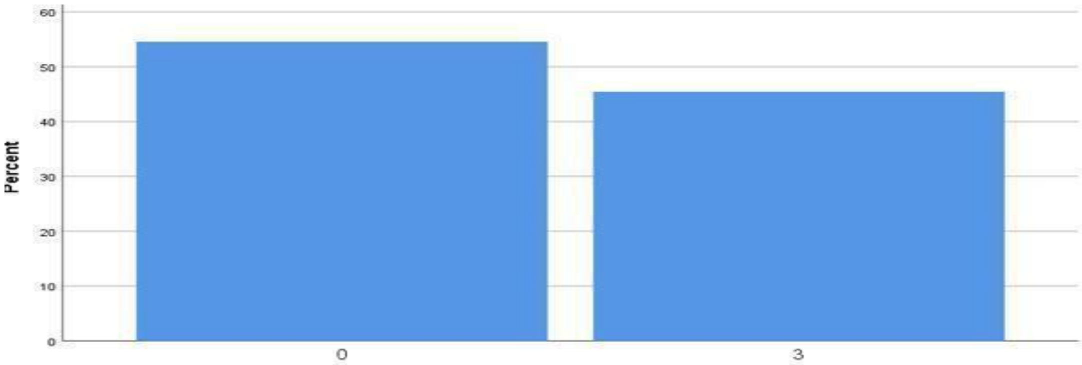


Figure 23: Type of disease surveillance

The bar graph shows the type of healthcare information the participant access, communicate and exchange with other public hospitals in Namibia is disease surveillance data in addition to specific disease information such as malaria, HIV/AIDS and cancer. The zero on the bar graph represents 56% who indicated that the type of disease surveillance data exchanged and communicated among public hospitals are malaria, HIV/AIDS and cancer and 3 on the bar graph represents 45% of participants who indicated that the current methods used to exchange and communicate disease surveillance data is manual paper based systems.

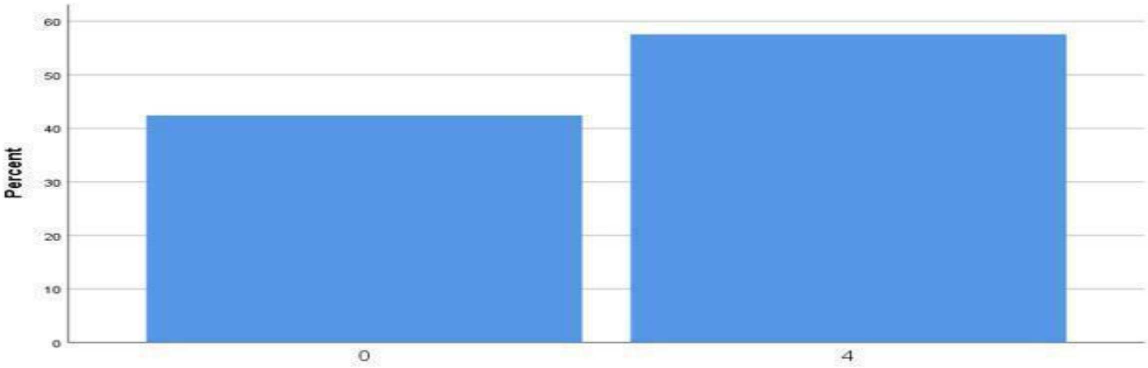


Figure 24: Preference of receiving disease surveillance data

The bar graph shows the participants who indicated that they preferred accessing, exchanging and communicate disease surveillance data with other hospital through mobile phone. The zero on the bar graph represents 42% of participants who indicated that they prefer to receive disease surveillance data among public hospitals through mobile phone and the 4 on the bar graph represents 55% of participants who indicated that the current methods used in public hospitals to exchange and communicate disease surveillance data is manual paper based systems.

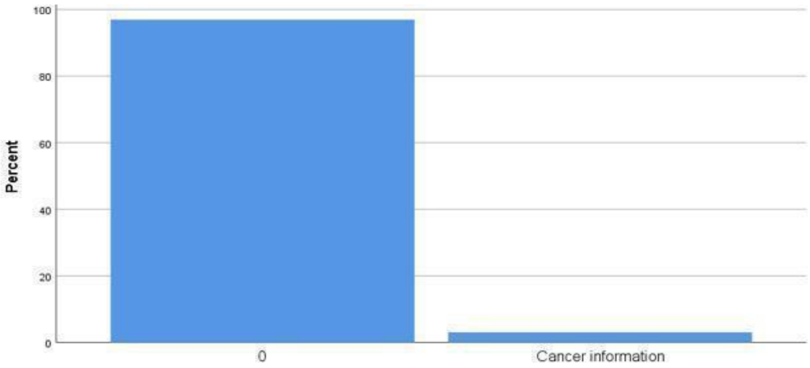


Figure 25: Type of disease surveillance respondents want to receive

The bar graph shows the type of healthcare information public hospitals receive, exchange and communicate with other public hospitals in Namibia in addition to disease surveillance data that is shared through traditional methods such as circular, physically visiting the health facilities. The zero on the bar graph represents 89% participants who indicated that the current methods used to receive disease surveillance data is manual paper based systems and cancer information on the bar graph represents 1% of participants who indicated that they prefer to receive disease surveillance data through a paper manual system.

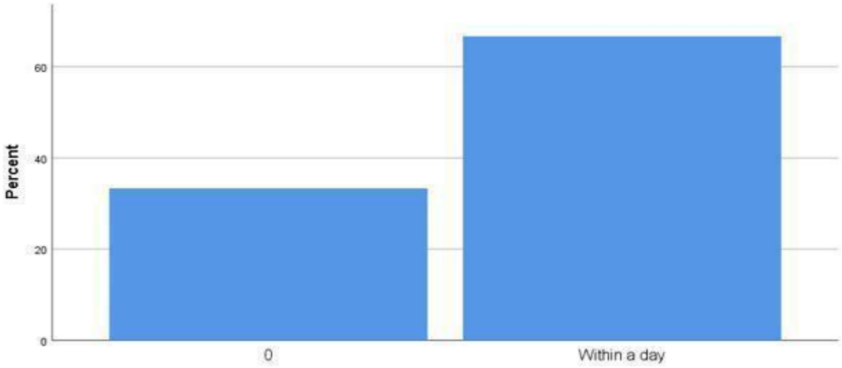


Figure 26: Duration it takes to receive disease surveillance data

The bar graph shows the length of time it takes to access, communicate, exchange and share disease surveillance data from one public hospital to the other hospital. The zero on the bar graph represents 30% of participants who indicated that it takes on average a month to receive disease surveillance data and within a day on the bar graph represents 64% of participants who indicated that it doesn’t take within a day to receive disease surveillance data among public hospitals in Namibia.

5.2.5 Ohangwena region public hospitals response rate

Table 35: Ohangwena region public hospitals response rate

Questions	Response rate	Number of Ohangwena participants
As public hospital, how do you exchange disease surveillance data within other hospitals?	The participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective.	**30**
How do you access disease surveillance data from other hospitals in Namibia?	The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems.	**30**
What type of disease surveillance data from other public hospitals in	The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and	**30**

Namibia ?	national level are Sentinel Surveillance, Accelerated Disease Control - National Active and National Passive.	
How would You Prefer to Receive disease surveillance data from other public hospitals?	The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.	**30**

A total of 30 participants (including males and females) stated that public hospitals and health institutions in Namibia currently access, exchange, communicate and share disease surveillance data manually with other public health institutions and the most common method used to share health related information is through circular, etc.

Table 36: Gender response rate from Ohangwena region

GENDER	Frequency	Percent	Cumulative Percent
MALE	16	47.1	53.3
FEMALE	14	41.2	100.0
Total	30	88.2	100.0

The table shows the number of females and males. The males were 16, females were 14 of which 53.3% represented males and 46.7% represented females.

Table 37: Age group response rate from Ohangwena

AGE GROUP	Frequency	Percent	Cumulative Percent
18-25	2	5.9	6.7
26-35	18	52.9	66.7
36-45	6	17.6	86.7
ABOVE45	4	11.8	100.0
Total	30	88.2	

The table shows the age group between 18-25 years which was only represented by 2 participants, 26-35 years were 18 with percentages of 60%, the age group between 36-45 years was 6 with 20% and the age group above 45 years was 4 with 13.3%.

Table 38: Exchange disease surveillance data

Methods of exchanging Disease surveillances	Frequency	Percent	Cumulative Percent
Manual paper based systems	23	67.6	76.7
Through mobile phone	7	20.6	100.0

Total	30	88.2

The participants both females and males indicated that the current method used by health public institutions in Namibia is a manual system which is not effective and efficient in exchanging, sharing, communicating disease surveillance data from one public hospital to the other health public hospitals operating in the same environment. These percentages mean the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 39: Accessing disease surveillance data

Methods of accessing Disease surveillance Data	Frequency	Percent	Cumulative Percent
Through mobile phone	12	35.3	40.0
Visit the Hospital or Clinic	1	2.9	43.3
Manual paper based systems	17	47.1	96.7
Smartphone	1	2.9	100.0
Total	30	88.2	100.0

The participants, both female and male, indicated that the current method used by Namibian public hospitals is manual process which is time consuming when another public health institution wants to access, exchange, communicate disease surveillance information with other health institutions. The participants further stated that they access disease surveillance information through visiting hospitals and clinics. These percentages mean the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 40: Type of disease surveillance data

Type of disease surveillance Data	Frequency	Percent	Cumulative Percent
Sentinel Surveillance	14	41.2	46.7
National Passive	1	2.9	50.0
National Passive	1	2.9	53.3
surveillance Data	14	41.2	100.0
Total	30	88.2	100.0

The participants, both male and female, stated that the type of healthcare information they exchange, communicate and share with other public institutions is campaign related to health with 1 and the percentage is 3.3% and also their health record which is 1 which constitutes 3.3% and 14 participants indicated that. These percentages mean the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive.

The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 41: Preference to receive disease surveillance data

Preference to receive disease surveillance Data	Frequency	Percent	Cumulative Percent
Manual paper based systems	8	23.5	26.7
Visit the Hospital or Clinic	1	2.9	30.0
Through mobile phone	1	2.9	33.3
Flyers	1	2.9	36.7
None-smartphone	19	55.9	55.9
Total	30	88.2	88.2

The participants both male and female indicated that they preferred accessing, exchanging and communicating disease surveillance data through mobile phone rather than through visiting the hospital or clinic. Majority of males and females preferred mobile phone as a means of exchanging, communicating disease surveillance data from one hospital to the other hospital. These percentages mean the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease Control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 42: Type disease surveillance data respondents want to receive

Types of Disease surveillance Data	Frequency	Percent	Cumulative Percent
Sentinel Surveillance	28	82.4	93.3
National Passive	1	2.9	96.7
Sentinel Surveillance	1	2.9	100.0
Total	30	88.2	100.0

Both males and females stated that the type of healthcare information they would want to access, exchange and communicate with other public hospitals is disease surveillance data in addition to specific disease information such as Sentinel Surveillance and National Passive information with 3.3%. These percentages mean the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 43: Duration it takes to receive disease surveillance data

Periods it takes to receive Disease surveillance Data	Frequency	Percent	Cumulative Percent
A month on Average	8	23.5	26.7
Within a day	22	64.7	100.0
Total	30	88.2	100.0

The participants indicated that it took longer to receive, exchange and communicate disease surveillance data from one health institutions to the other which takes on average about a month and this delays the process of exchanging disease surveillance data within hospitals. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

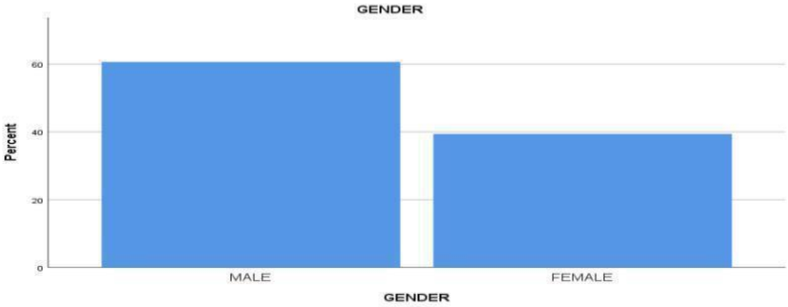


Figure 27: Pie chart gender response rate

The pie chart shows both males and females. The red part represents female and the blue area represents male who symbolised the method used by public health institutions to exchange and communicate disease surveillance data.

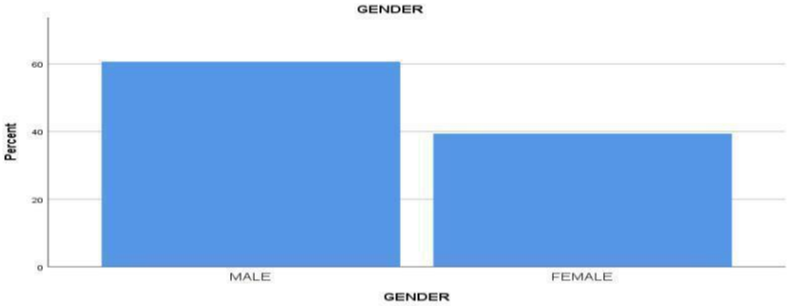


Figure 28: Pie chart age group response rate

The pie chart represents the participants in age groups between 18-25 years, 26-35 years, 36-45 years and above 45 years. The blue area represents the age group between 18-25 years, the red area represents age group between 26-35 years, the green area represents age group between 36-45 years and the last age group represents age group above 45 years which is orange.

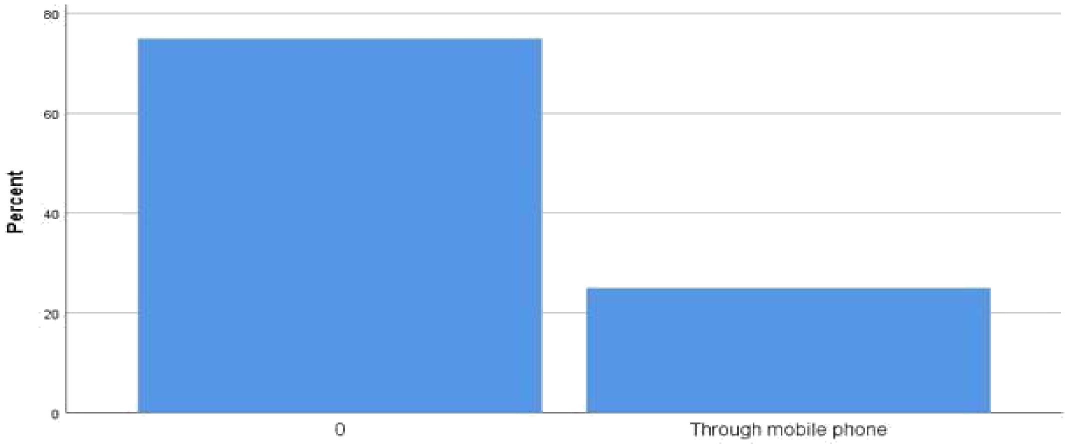


Figure 29: Bar graph chart exchange disease surveillance data

The pie chart shows the participants who indicated the methods they used to exchange, communicate disease surveillance data from one public hospital to the other public hospital which is a manual process such as circular, phone call and email. The zero on the bar graph represents 70% of participants who indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems and 21% represents participants who indicated that they do not use mobile phones as a method of exchanging and communicating disease surveillance data among hospitals in Namibia.

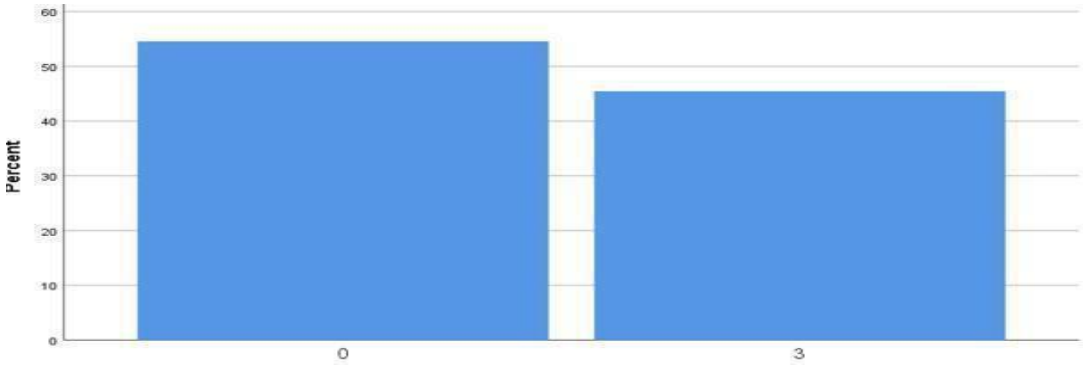


Figure 30: Bar graph accessing disease surveillance data

The pie chart shows the participants indicated that they access, communicate and exchange disease surveillance data through visiting hospitals or clinics and they prefer receiving, communicating and exchanging disease surveillance data through mobile phone. The zero on the bar graph represents 55% of participants who indicated that they access disease surveillance data through a manual systems and 3 on the bar graph represents 45% of participants who indicated public hospitals in Namibia do not communicate and exchange disease surveillance data through mobile phone.

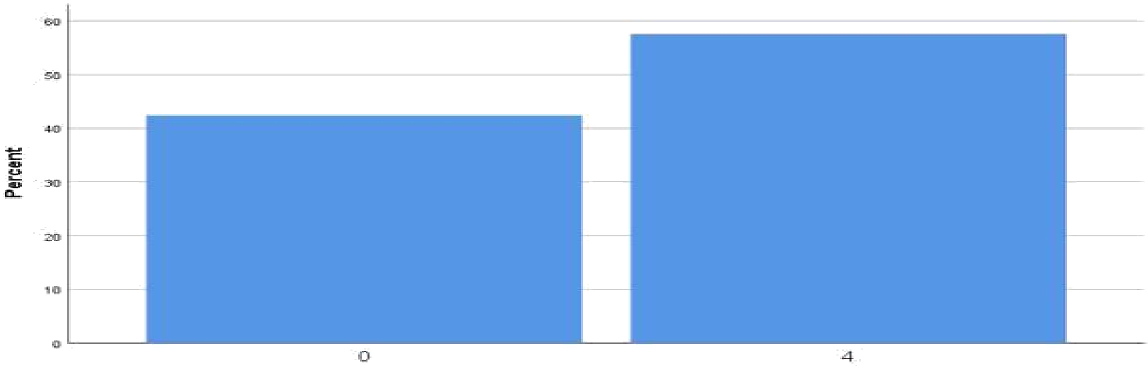


Figure 31: Type of disease surveillance data

The bar graph chart shows both males and females who indicated that the type of healthcare information they receive from one public hospital to the other public hospital is disease surveillance data such as Sentinel Surveillance and National Passive. The zero on the chart represents 41% of Sentinel Surveillance and the 4 on the chart represents National Passive with 55% exchanged and communicated among hospitals in Namibia.

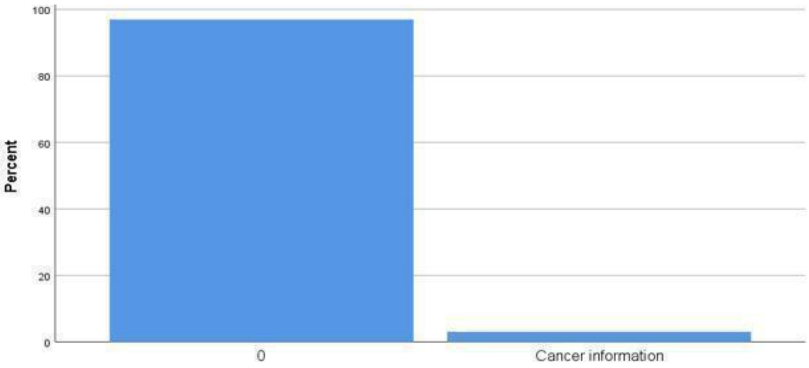


Figure 32: Preference to receive disease surveillance data

The bar graph chart shows the participants who stated that they preferred to receive, exchange and communicate disease surveillance data through mobile phone. The current method used by public hospitals or health institutions in Namibia is a manual system which includes visit the hospital or clinics or through flyers distributed at health facilities across the country in all the 14 regions. The zero on the bar graph represents 90% of participants who indicated that Namibia public hospital exchange and communicate disease surveillance data through a manual paper based systems and the cancer information represents 1% of participants who also indicated mobile phone is not used as methods of communicating and exchanging disease surveillance data.

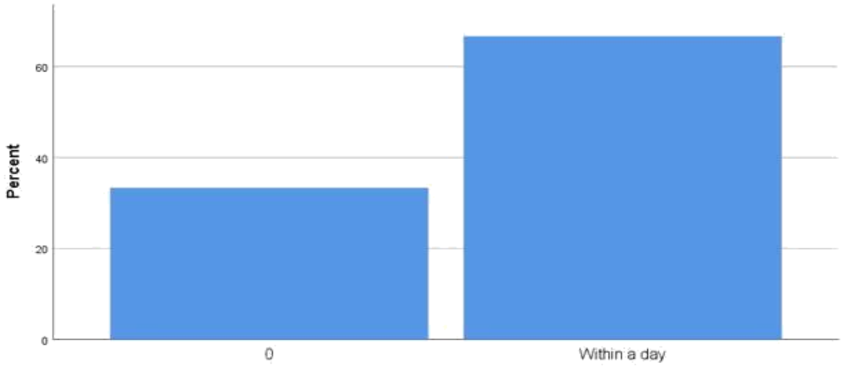


Figure 33: Duration it takes to receive the information

The pie chart shows how long it took for one public hospital to access, exchange and communicating disease surveillance data with other public hospitals. The red area indicates the longer it takes for one public hospital to receive, exchange and communicate disease surveillance data with other public hospitals. The zero on the bar graph represents 26% of participants who indicated that it takes a month on average to receive and access disease surveillance data among hospitals in Namibia and within a day on the bar graph represents 65% of participants who indicated that it is hard to receive disease surveillance data within a day from regional level to the national level due to the current manual paper based systems in place at the present moment.

5.2.6 Omusati region public hospitals response rate

Table 44: Duration it takes to receive disease surveillance data

Questions	**Response rate**	**Number of Omusati participants**
As public hospital, how do you exchange disease surveillance data within other hospitals?	The participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective.	**27**
How do you access disease surveillance data from other hospitals in Namibia and for how long?	The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems.	**27**
What type of disease surveillance data from other public hospitals in Namibia in percentage?	The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are	**27**

	Sentinel Surveillance, Accelerated Disease Control - National Active and National Passive.	
How would You Prefer to Receive disease surveillance data from other public hospitals ?	The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.	**27**

A total of 27 participants, which includes both males and females, participated and stated that the current methods of exchanging, communicating disease surveillance data is a manual system which is not appropriate when health professionals are making health strategic decisions.

Table 45: Gender response rate from Omusati region

GENDER	Frequency	Percent	Cumulative Percent
MALE	12	44.4	44.4
FEMALE	15	55.6	100.0
Total	27	100.0	

The table shows both males and females. The number of male was 12 and the number of females was 15. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 46: Age group response rate

AGE GROUP	Frequency	Percent	Cumulative Percent
18-25	7	25.9	25.9
26-35	11	40.7	66.7
36-45	4	14.8	81.5
ABOVE45	5	18.5	100.0
Total	27	100.0	25.9

The table shows the age groups between 18-25 years with 7, age group between 26-35 years with 11, age group between 36-45 years with 4 and above 45 years with 5. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 47: Exchange disease surveillance data

	Frequency	Percent	Cumulative Percent
0	15	55.6	55.6
Through mobile phone	12	44.4	100.0
Total	27	100.0	

The participants indicated that the current method used to exchange and communicate disease surveillance data is through a manual process which is not appropriate in exchanging disease surveillance when data is needed urgently. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 48: Accessing disease surveillance data

	Frequency	Percent	Cumulative Percent
0	14	51.9	51.9
Visit the Hospital or Clinic	1	3.7	55.6
Through mobile phone	12	44.4	100.0
Total	27	100.0	

The participants indicated that they access, communicate and exchange disease surveillance data through visiting the hospital or clinic and they prefer receiving, exchanging and communication such information through mobile phone. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 49: Type of disease surveillance data

Types of Disease surveillance	Frequency	Percent	Cumulative Percent
Sentinel Surveillance	18	66.7	66.7
Accelerated Disease Control -National Active	2	7.4	74.1
National Passive	7	25.9	100.0
Total	27	100.0	100.0

The participants indicated that the type of healthcare information they exchanged and communicated to other public hospitals was disease surveillance information in addition to their health record. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 50: Preference to receive disease surveillance data

Preference to receive disease surveillance Data	Frequency	Percent	Cumulative Percent
Manual paper based systems	5	18.5	18.5
Mobile devices	3	11.1	29.6
Computers	19	70.4	100.0
Total	27	100.0	

The participants indicated that they preferred accessing, receiving, exchanging and communicating disease surveillance data through modern technology such as mobile phone, laptop, tablet and desktop computers. The participants indicated that the current method used to exchange and communicate disease surveillances data was through manual paper based systems. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 51: Type of disease surveillance data respondents want to receive

Types of Disease surveillance	Frequency	Percent	Cumulative Percent
Sentinel Surveillance.	26	96.3	96.3
Accelerated Disease Control	1	3.7	100.0
- National Active			
Total	27	100.0	96.3

The participants indicated that the type of healthcare information they wanted to access, receive, exchange and communicate with other public hospitals was disease surveillance data in addition to cancer information. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 52: Duration it takes to receive disease surveillance data

Periods it takes to receive Disease surveillance Data	Percent	Valid Percent	Cumulative Percent
A month on Average	25.9	25.9	25.9
Within a day	70.4	70.4	96.3
A month on Average	3.7	3.7	100.0
A month on Average	100.0	100.0	25.9

The participants indicated that it took longer for one public hospital or public health institutions to access, receive, exchange and communicate disease surveillance data with other public hospitals or other public health institutions. The participants further indicated that 70.4% agreed that it was impossible to access, exchange and communicate disease surveillance data within a day. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated

surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

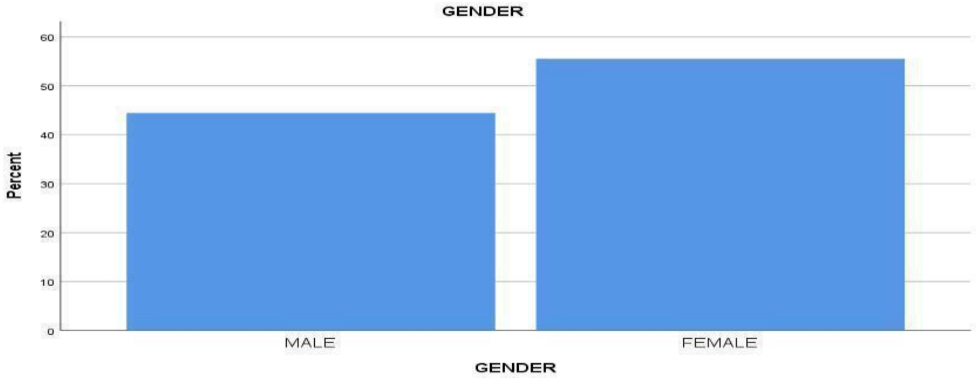


Figure 34: Gender response rate

The bar graph shows both gender male and female which indicated that male were 45% and females were 55% who indicated that they prefer modern technology to access, exchange and communicate disease surveillance data from one public hospital to the other public hospitals.

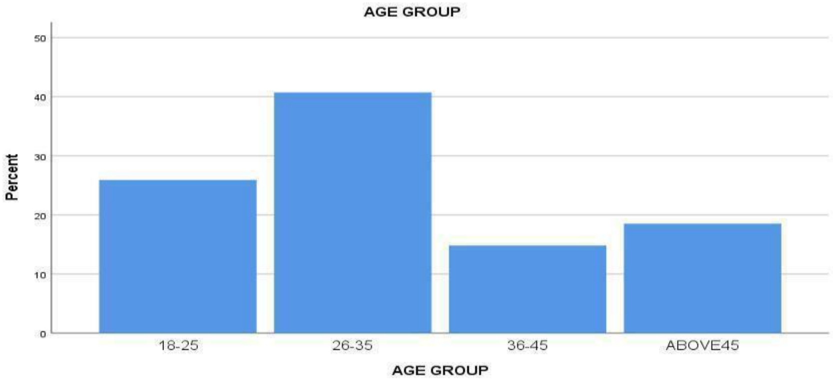


Figure 35: Age group response rate

The bar graph shows both gender male and female which indicated that males were 45% and females were 55% who indicated that they preferred modern technology to access, exchange and communicate disease surveillance data from one public hospital to the other public hospitals.

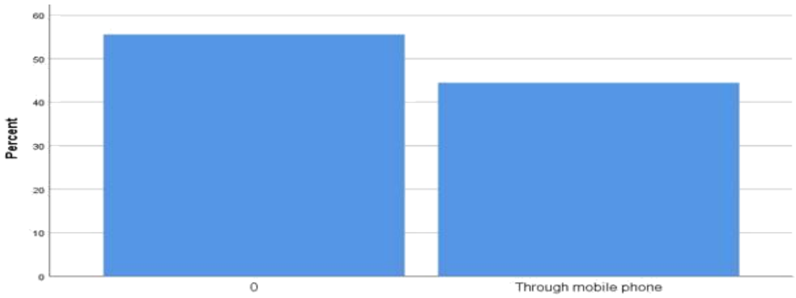


Figure 36: Exchange disease surveillance data

The participants indicated that the current method used in Namibian public hospitals was a manual process. If one hospital needs disease surveillance data from another public hospital it took on average a month to get such information from all the 14 regions in Namibia. However, the participants indicated that they preferred accessing, receiving, exchanging and communicating disease surveillance data through mobile phone. The zero on the bar graph represents 65% of participants who indicated that the current methods used to exchange and communicate disease surveillance data among public hospitals in Namibia is a manual paper based systems and through mobile phone on the bar graph represents 45% participants who indicated that they prefer to receive disease surveillance data through mobile phone among public hospitals.

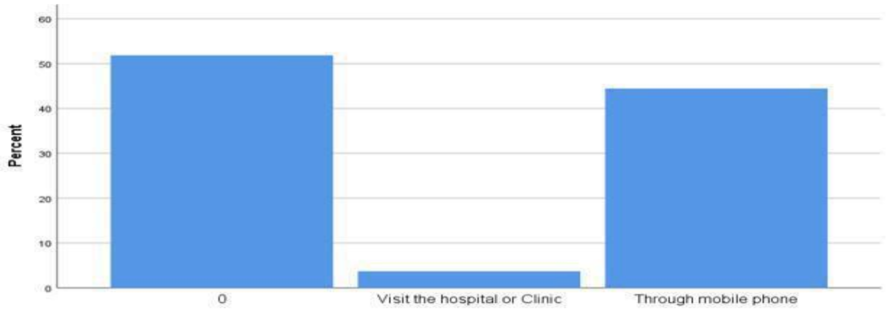


Figure 37: Accessing disease surveillance data

The bar graph shows the number of participants in percentages who indicated that the current method to receive, access, exchange and communicate disease surveillance data to another public hospital is through visiting the hospital or clinic. The mobile phones are used to call other health professionals but not used as means of aggregating disease surveillance data with other hospitals in Namibian health sector. The zero on the bar graph represents 63% of participants who indicated that they exchange and communicate disease surveillance data among each other through a manual paper based systems, visits the hospital or clinic on the bar graph represents 1% of participants who want to visit hospitals or clinic to access disease surveillance data and through mobile phone 45% of participants indicated that they prefer to access disease surveillance data through mobile phone among each public hospital in Namibia.

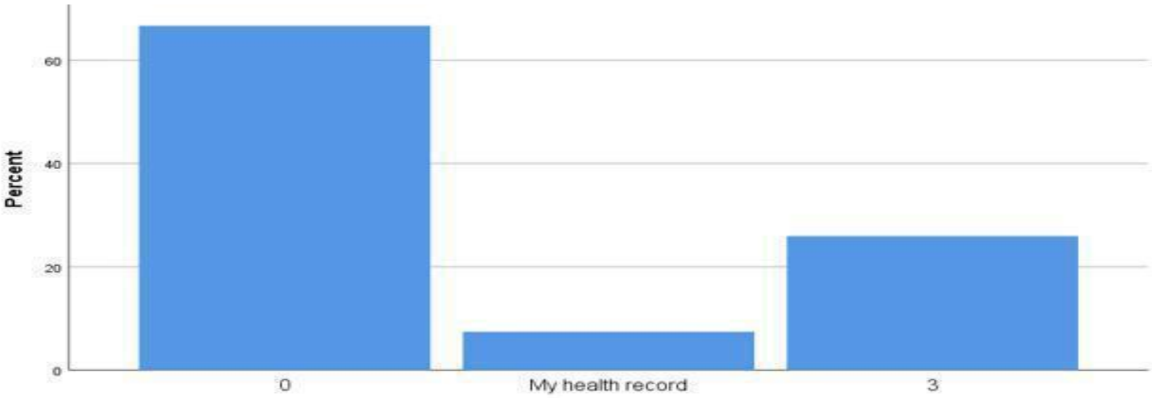


Figure 38: Type of disease surveillance data

The bar graph shows the type of healthcare information being exchanged, communicated, received, and accessed from one public hospital to the other public hospitals, which is disease surveillance data in addition to their health record. The zero on the bar graph represents 65% of participants who indicated that the type of disease surveillance data they exchange and communicate between hospitals is patient demographic data, my health record on the bar graph represents 12% of participants who indicated that the type disease surveillance data they exchange and communicate among each other is their health record and 3 on the bar graph represents 25% of participants who indicated that the current methods used in public hospitals in Namibia is manual paper based systems .

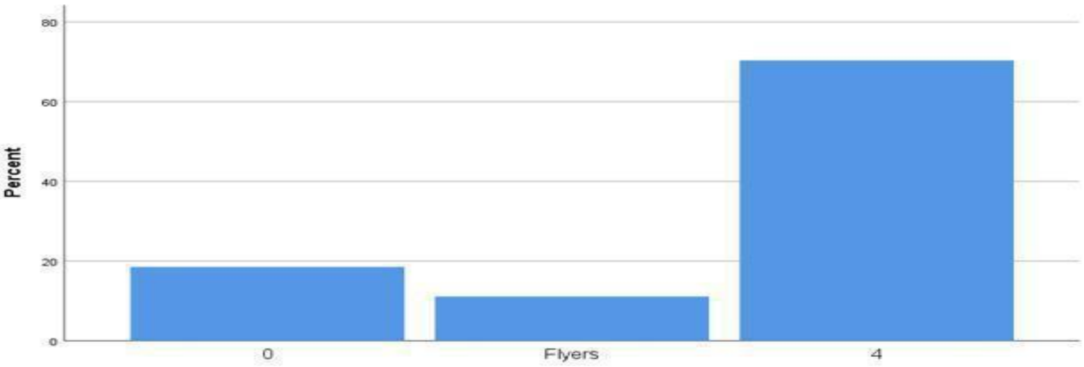


Figure 39: Preference to receive disease surveillance data

The bar graph shows the number of participants in percentages who indicated that they preferred to access, receive, exchange and communicate disease surveillance data through modern technology such mobile phone, tablet, laptop and means of communication platform among public hospital and public health institutions in Namibia. The participants also indicated that they do not prefer flyers as means of communicating, exchanging, receiving and accessing disease surveillance data among public hospitals in Namibia. The zero on the bar graph represents 19% of participants who indicated that they prefer to receive disease surveillance data through mobile phone, flyers on the bar graph represents 15% of participants who indicated that they receive disease surveillance data through flyers and 4 on the bar graph represents the 65% participants who indicated that they prefer to receive disease surveillance data through an integrated health information systems that can aggregate data from different public hospitals in the 14 region of the country.

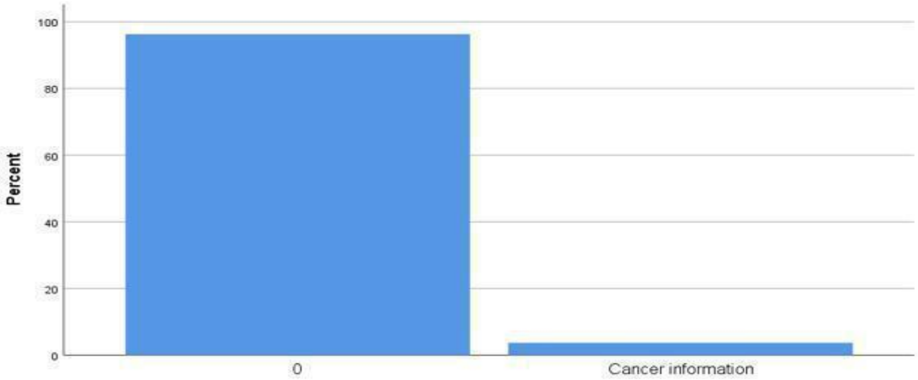


Figure 40: Type of disease surveillance data respondents want to receive

The bar graph shows the number of participants in percentages who indicated that the type of healthcare information they wanted to access, receive, communicate and exchange with other public hospitals is disease surveillance data in addition to specific disease information such as cancer information. The percentages of participants who preferred to receive, exchange, communicate disease surveillance data were 90% while for cancer information were 2%. This means majority of the participants preferred receiving, accessing, communicating and exchanging disease surveillance data through modern technology. The zero on the bar graph represents 90% of participants who indicated that Namibian public hospitals have manual paper based systems to exchange and communicate disease surveillance data among each other and cancer information on the bar graph represents 2%

of participants who indicated that they do not receive cancer information through mobile phone.

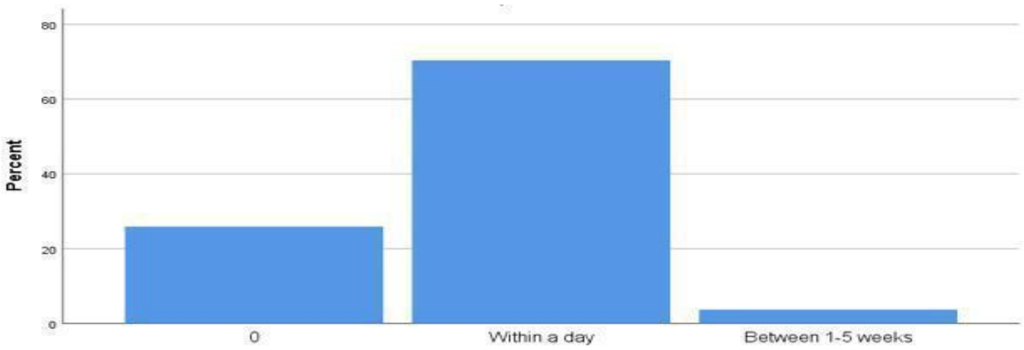


Figure 41: Duration it takes to receive disease surveillance data

The bar graph shows the participants indicated that it took longer to receive, access, exchange and communicate disease surveillance data from other public hospitals due to the fact that data is not kept at one central place from all the 14 regions in Namibia. The participants indicated that it does not take within a day to get the data or neither 1-5 weeks to get disease surveillance data. The zero on the bar graph represents 24% of participants who indicated it takes on average a month to receive disease surveillance data among hospitals, within a day on the bar graph represents 65% participants who indicated that it doesn't take within a day to receive disease surveillance data within public hospitals in Namibia and between 1-5 weeks on the bar graph represents participants who indicated that it takes more than 1-5 weeks to receive disease surveillance data among public hospitals in Namibia.

5.2.7 Otjozondjupa region public hospitals response rate

Table 53: Otjozondjupa region public hospitals response rate

Questions	**Response rate**	**Number of Otjozondjupa participants**
As public hospital, how do you exchange disease surveillance data within other hospitals?	The participants indicated that the current methods to exchange surveillance data between is manual paper based system which is time consuming sending the data.	**21**
How do you access disease surveillance data from other hospitals in Namibia and for how long?	Different hospitals have a truck driver who transport manual paper based to the main head office in Windhoek.	**21**
What type of disease surveillance data is exchanged from one public hospitals to another in	The participants indicated that the type of disease surveillance data exchanged between hospital includes Sentinel Surveillance, Accelerated Disease Control - National Active and	**21**

Namibia?	National Passive.	
How would You Prefer to Receive disease surveillance data from other public hospitals?	The participants indicated that Public hospitals in Namibia should adopt integrated health information that will aggregate data from different hospitals in Namibia.	**21**

A total of 21 participants indicated that as public hospital in Namibian they access, exchange, communicate disease surveillance data from one hospital to the other through a traditional manual system.

In Otjozondjupa region majority of the participants pointed that Public hospitals in Namibia is manual paper based systems to exchange and communicate disease surveillance between public hospitals. The participants further indicated that there are no integrated health information and they proposed an integrated health information system that can aggregate surveillance data from one public hospital to another.

Table 54: Gender response rate from Otjozondjupa region

GENDER	Frequency	Percent	Cumulative Percent
MALE	10	37.0	47.6
FEMALE	11	40.7	100.0
Total	21	77.8	100.0

The table shows both male and female based on their gender. The number of males was 10, females were 11. The percentage of males was 47.6% and the percentage of females was 52.4%. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 55: Age response rate from Otjozondjupa region

AGE GROUP	Frequency	Percent	Cumulative Percent
18-25	2	7.4	9.5
26-35	9	33.3	52.4
36-45	5	18.5	76.2
ABOVE45	5	18.5	100.0
Total	21	77.8	100.0

The table shows the representation of age groups, between age group 18-25 years, the age group 26-35 years, the age group between 36-45 years, age group above 45 years. The percentage of age group between 18-25 years was 9.5%, the age group between 26-35 years was 42.9%, the age group 36-45 years was 23.8% and the age group above 45 years was 23.8%.

Table 56: Exchange of disease surveillance data

Methods of exchanging Disease surveillance Data	Percent	Cumulative Percent
Mobile phones	25.9	33.3
Manual paper based systems	51.9	100.0
Flyers	77.8	100.0

The participants indicated that they preferred exchanging, communicating, receive and access disease surveillance data through mobile phone. The number of participants involved indicated that the current method used to exchange and communicate disease surveillance data through a manual system which is inappropriate when getting disease surveillance from other hospitals or other health public institutions. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 57: Accessing disease surveillance data

Methods of accessing Disease surveillance Data	Frequency	Percent	Cumulative Percent
Through mobile phone	16	59.3	76.2
Manual paper based systems	5	18.5	100.0
Total	21	77.8	100.0

The participants indicated that they accessed disease surveillance data through a manual system such as email, telephone, circular and physically visiting health facilities. Therefore, they suggested moving to a modern technology through using mobile phone, tablet, laptop and computer desktop. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 58: Type of disease surveillance data

Types of Disease surveillance Data	Frequency	Percent	Cumulative Percent
Sentinel Surveillance	5	18.5	23.8
National Passive	1	3.7	28.6
Accelerated Disease Control - National Active	15	55.6	100.0
Total	21	77.8	100.0

The participants indicated that the type healthcare information they received, accessed, communicated and exchanged apart from disease surveillance data was their health record. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 59: Preference to receive disease surveillance data

Preference to receive disease surveillance Data	Frequency	Percent	Cumulative Percent
Flyers	11	40.7	52.4
Computers	1	3.7	57.1
Mobile phones	9	33.3	100.0
Total	21	77.8	52.4

The participants indicated that they do not prefer to access, receive, exchange and communicate disease surveillance through flyer. Therefore, they preferred to access disease surveillance data through mobile phone or through modern technology such tablet, smartphone, laptop and desktop computer. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 60: Type of disease surveillance respondents want to receive

Types of Disease surveillance Data	Frequency	Percent	Cumulative Percent
Sentinel Surveillance	21	77.8	100.0
National Passive	0	22.2	22.2
Total	**21**	100.0	100.0

The participants indicated that the type of healthcare information they wanted to access, receive, exchange and communicate among public hospitals was disease surveillance data. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 61: Duration it takes accessing disease surveillance data

Periods it takes to access Disease surveillance Data	Frequency	Percent	Cumulative Percent
Within a day	7	25.9	33.3
A month on Average	14	51.9	100.0
Total	21	77.8	100.0

The participants indicated that it took longer than expected to access, communicate and exchange disease surveillance data through a manual system used by public hospitals. It took many days to receive, access, exchange and communicate disease surveillance data when exchanging, communicating, accessing and receiving from public hospitals. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

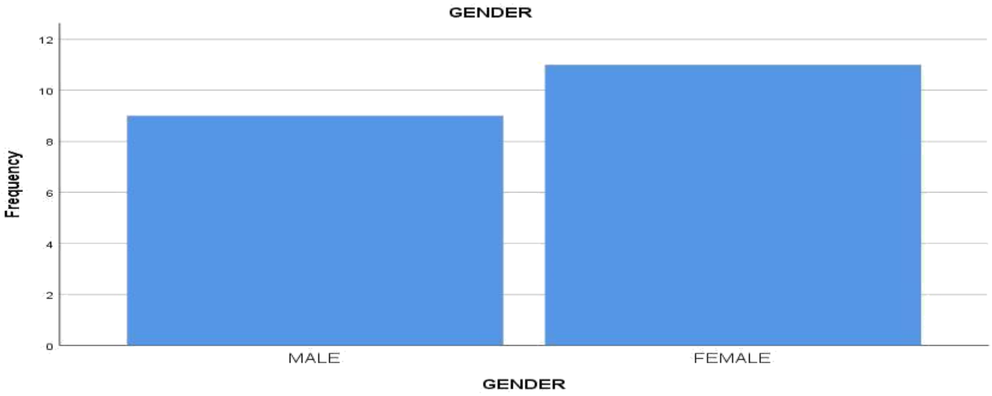


Figure 42: Bar graph chart gender response rate

The bar graph chart show both males and females based on their gender. The red area represents female and the blue area represents blue. The males on the bar graph represents 9% of participants and female 11% indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

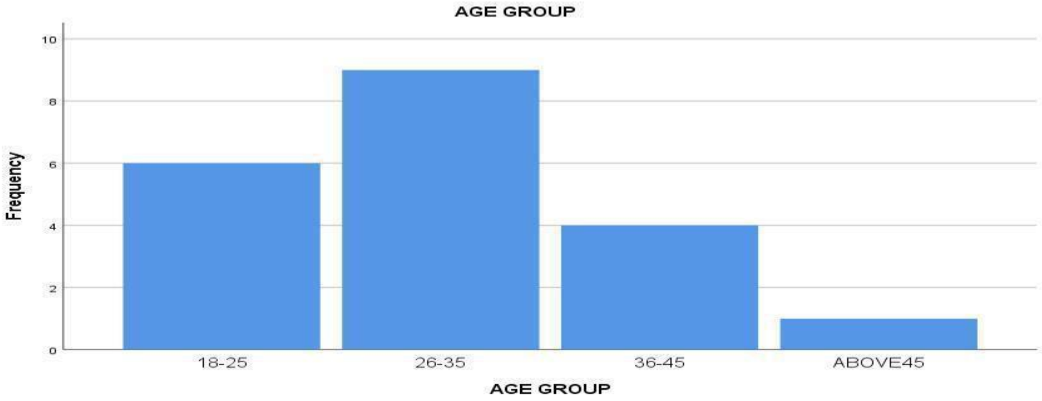


Figure 43: Bar graph chart age group response rate

The pie chart represents the age group between 18-25 years is represented by a blue colour group, the age group between 26-35 years is represented by a red colour, the age between 36-45 years is represented by a green colour and the age group above 45 years is represented by the orange colour.

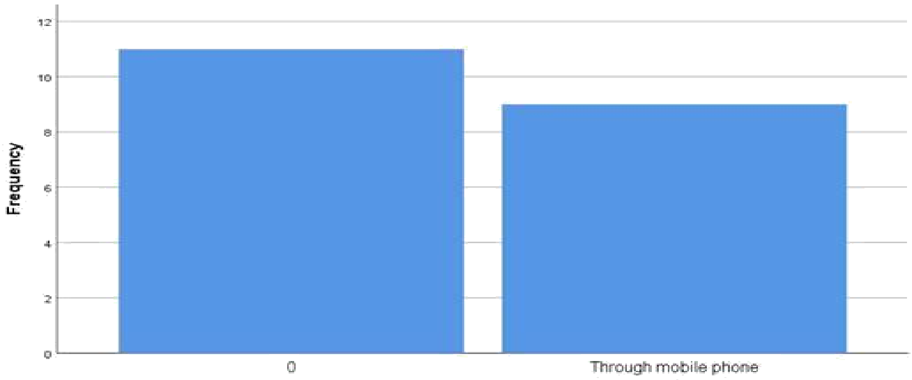


Figure 44: Exchange disease surveillance data

The pie chart shows the participants that are represented based on their gender who stated that the current method used to exchange, access, receive and communicate disease surveillance data is from one public hospital to other hospital is a manual process which is not efficient and effective in terms of exchanging and communication disease surveillance data between hospitals in Namibia. The participants indicated that they preferred receiving disease surveillance data through mobile phone from other public hospital. The zero on the bar graph represents 11% of participants indicated that they exchange and communicate disease surveillance data through manual paper based systems and through mobile phone 9% on the bar graph represents indicated that they do not access and receive disease surveillance data through mobile phone.

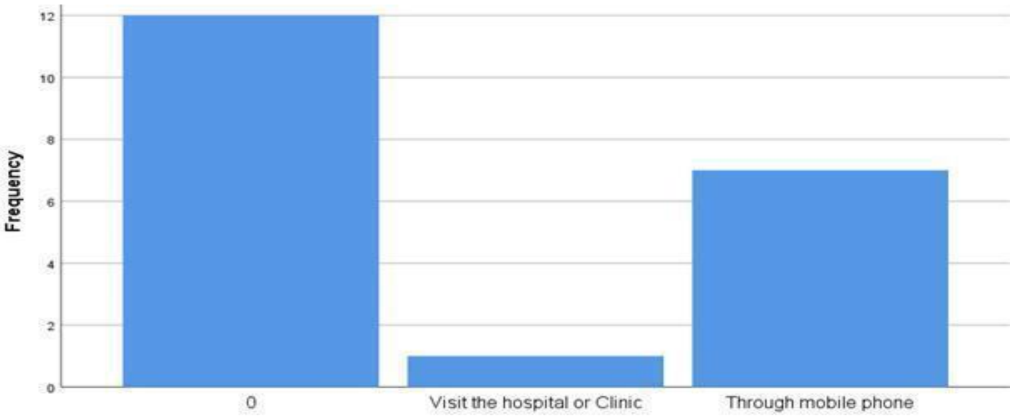


Figure 45: Accessing disease surveillance data

The bar graph chart shows the participants who indicated that they access, receive, exchange and communicate data through modern technology such as tablet, mobile phone, laptop and computer desktop. The blue colour represents participants that indicated that the current method used by public hospital from one to other hospitals is a manual process such as through flyers, circular and pamphlet. The zero on the bar graph represents 12% of participants indicated that they receive and access disease surveillance through manual paper based systems, visit the hospital or clinic represents 1% of participants who indicated that they access disease surveillance data through visiting public hospitals or clinics and through mobile phone on the bar graph represents 7% of participants who indicated that they do not access disease surveillance data through mobile phone.

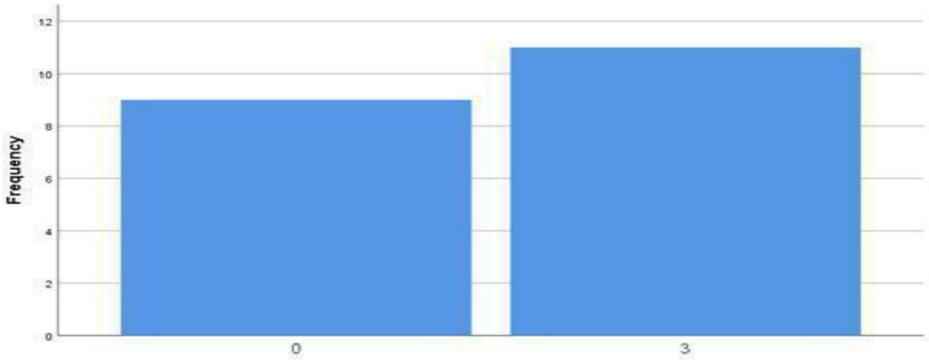


Figure 46: Type of disease surveillance data

The pie chart shows the type of disease surveillance data that participants from one public hospital in Namibia who indicated that the current method used to exchange, communicate, receive and access disease surveillance data is manual system such as circular, pamphlets, email, telephone and flyers. The zero on the bar graph represents 9% of participants indicated that they use manual paper based systems to exchange and communicate disease surveillance and the 3 on the bar graph represents 11% of participants who indicated that Namibian public hospitals use manual paper based systems to disseminate disease surveillance data from the regional level and national level.

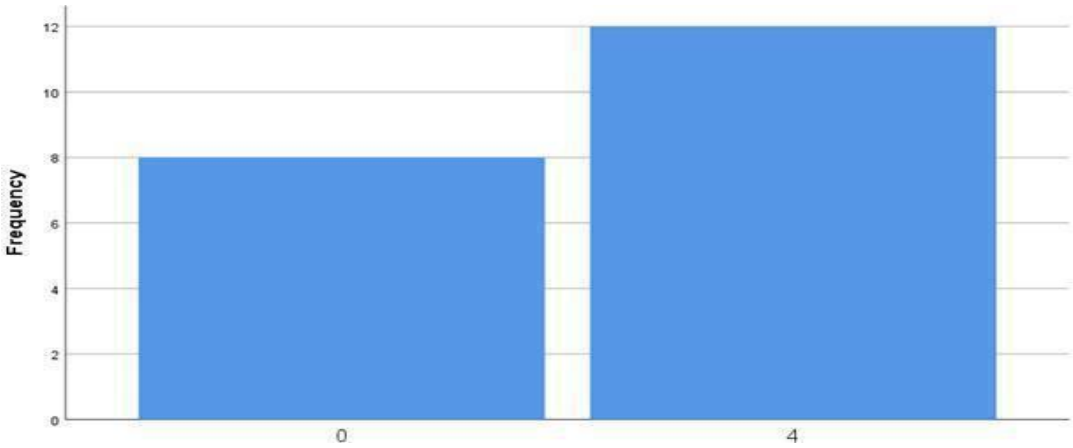


Figure 47: Preference to receive disease surveillance data

The bar graph chart shows the participants who indicated that they preferred to access, receive, exchange and communicate disease surveillance data through modern technology such mobile phone. The participants further stated that the current method used to exchange, communicate, access and receive disease surveillance data is through flyers, emails, pamphlets. The participants further indicated that public hospitals in Namibia should come up with a mechanism that will allow public hospitals in Namibia to access, receive, exchange and communicate disease surveillance data using a technology platform as a means of communication methods. The zero on the bar graph represents 8% of participants indicated that they prefer to receive disease surveillance data through mobile phone.

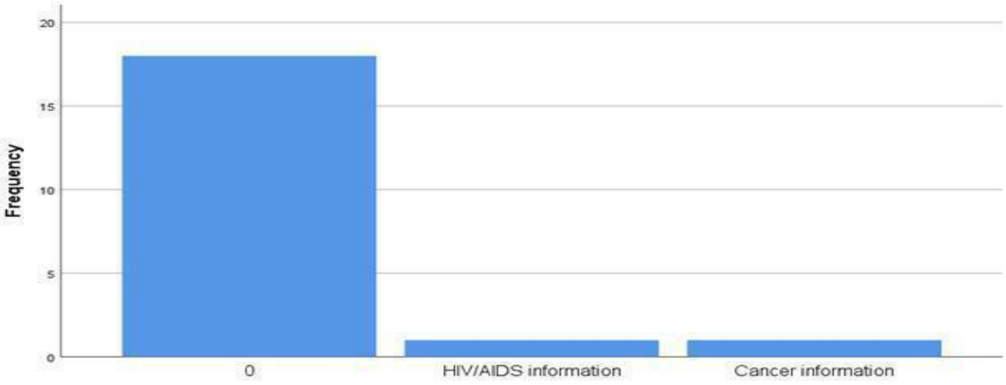


Figure 48: Type of disease surveillance data

The pie chart shows the participants who indicated that the type of healthcare information they want to access, receive, exchange and communicate with other public hospitals or other health public institutions is disease surveillance data in addition to their health record. The zero on the bar graph represents the 16% of participants who indicated that the type of disease surveillance data were HIV/AIDS with 1% and 1% of cancer information.

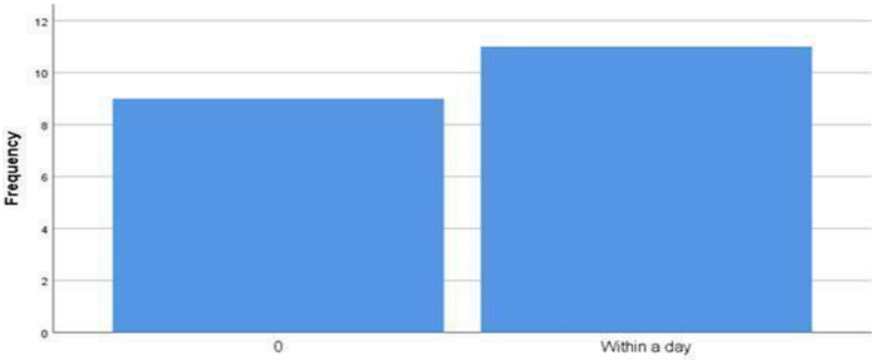


Figure 49: Duration it takes to receive disease surveillance data

The bar graph chart shows the majority of the participants who indicated that it took longer to receive, access, exchange and communicate disease surveillance data from one hospital to the other hospitals. The participants indicated that it took many days to receive, access, exchange and communicate disease surveillance data from one public hospital to the other. Therefore, the participants indicated that they preferred to receive, access, exchange and communicate disease surveillance data through a technology platform which will ensure disease surveillance data is accessed, received, exchanged and communicated among public hospitals in Namibia. The zero on the bar graph 9% of participants who indicated that it takes a month on average to receive disease surveillance data and within a day on the bar graph represents 11% who indicated that it doesn’t take within a day to receive disease surveillance data between public hospitals in Namibia.

5.2.8 Zambezi region public hospitals response rate **Table 62: Zambezi region public hospitals response rate**

Questions	**Response rate**	**Zambezi percentages response rates**
As public hospital, how do you exchange disease surveillance data within other hospitals?	The participants in Zambezi region indicated that they exchange and communicate disease surveillance data to other hospital through a manual paper based systems which are not efficient and effective in the delivery of surveillance data to the head office.	27
How do you access disease surveillance data from other hospitals in Namibia and how long?	The participants indicated that they access surveillance data through a manual paper based system which is not efficient and effective when receiving surveillance data.	27
What type of disease surveillance data is exchanged from one public	The participants indicated that all surveillance captured from the regional level are consolidated in a form of report and send to the national level	27

hospitals to another in Namibia?	through a manual paper based system.	
How would You Prefer to Receive disease surveillance data from other public hospitals?	The participants indicated that they prefer to receive disease surveillance data through an integrated health information systems that can aggregate disease surveillance data from other hospitals.	27

A total of 27 participants (both males and females) in Zambezi region participated in the interview questionnaires of which majority of the participants indicated that the current methods used in public hospitals or health public institutions in Namibia is a manual process which includes circular, email, telephone calls, circular, flyers and pamphlets which is not

appropriate in case of emergency when an incident is reported. The participants also indicated their preferences on how they wanted to access, receive, exchange and communicate disease surveillance data among public hospitals and other health public institutions in Namibia.

Table 63: Gender response rate from Zambezi region

GENDER	Frequency	Percent	Cumulative Percent
MALE	15	46.9	55.6
FEMALE	12	37.5	100.0
Total	27	84.4	100.0

The table shows both males and females who participated who also indicated that they preferred to access, communicate, receive and exchange disease surveillance data through modern technology such as the use of mobile phone, tablet, laptop and desktop computer. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 64: Age group from Zambezi region

AGE GROUP	Frequency	Percent	Cumulative Percent
18-25	6	18.8	22.2
26-35	13	40.6	70.4
36-45	5	15.6	88.9
ABOVE45	3	9.4	100.0
Total	27	84.4	

The table shows the age groups between 18-25 years, the age group between 26-35 years, the age group between 36-45 years, and the age group above 45 years. The percentages of age groups: between 18-25 was 22.2%, between 26-35 years was 48.1%, between 36-45 years was 18.5% and above 45 years was 11.15%. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 65: Exchange disease surveillance data

Methods of exchanging Disease surveillance Data	Frequency	Percent	Cumulative Percent
Through mobile phone	15	46.9	55.6
Manual paper based systems	12	37.5	100.0
Total	27	84.4	100.0

The participants (both males and females) indicated that the current methods used to access, exchange, receive and communicate disease surveillance data is manual process that takes time for one health professional in one hospital to access and communicate disease surveillance data from one hospital to other public hospitals and other health institutions in Namibia. The participants further indicated that they preferred to access, receive, exchange and communicate disease surveillance data through a modern technology such as the use of cellphone to communicate real time data to the head office. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel Surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 66: Accessing disease surveillance data

Methods of accessing Disease surveillance Data	Frequency	Percent	Cumulative Percent
Through mobile phone	16	50.0	59.3
Manual paper based Systems	11	34.4	100.0
Total	27	84.4	100.0

The participants indicated that in the Namibian public hospitals and public health institutions, there is no technology platform that allows health professionals to communicate, receive, access, communicate and exchange disease surveillance from one public health institutions to the other. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 67: Type of disease surveillance data participants want to receive

Types of Disease surveillance Data	Frequency	Percent	Cumulative Percent
Sentinel Surveillance	15	46.9	55.6
Accelerated Disease Control - National Active	12	37.5	100.0
National Passive	27	84.4	100.0
Total	27	84.4	100.0

The participants indicated that the type of healthcare information received, accessed, exchanged and communicated among public health institutions in Namibia was disease surveillance data that is manually done. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated

surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 68: Preference to receive disease surveillance data

Preference to receive disease surveillance data	Frequency	Percent	Cumulative Percent
Manual paper based systems	9	28.1	33.3
Through mobile phone	18	56.3	100.0
Total	27	84.4	100.0

The participants also indicated that they preferred to access, communicate, receive and exchange disease surveillance data from other public health institutions through modern technology such as tablet, mobile phone and so forth. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 69: Type of disease surveillance data respondents want to receive

Types of Disease surveillance Data	Frequency	Percent	Cumulative Percent
HIV/AIDS	26	81.3	96.3
Cancer information	1	3.1	100.0
Total	27	84.4	100.0

The participants indicated that the type of healthcare information exchanged, accessed, communicated and received among public health institutions in Namibia is a manual process which is not accurate in the delivery of exchange disease surveillance among public institutions in Namibia. This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

Table 70: Duration it takes to receive disease surveillance data

Periods it takes to receive Disease surveillance Data	Frequency	Percent	Cumulative Percent
Within a day	7	21.9	25.9
A month on Average	20	62.5	100.0
Total	27	84.4	25.9

The participants indicated that it took on average about a month for one public health institutions to access, exchange, receive and communicate disease surveillance data through the current manual systems used among public health institutions in Namibia This percentage means the cumulative percent, percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country**.**

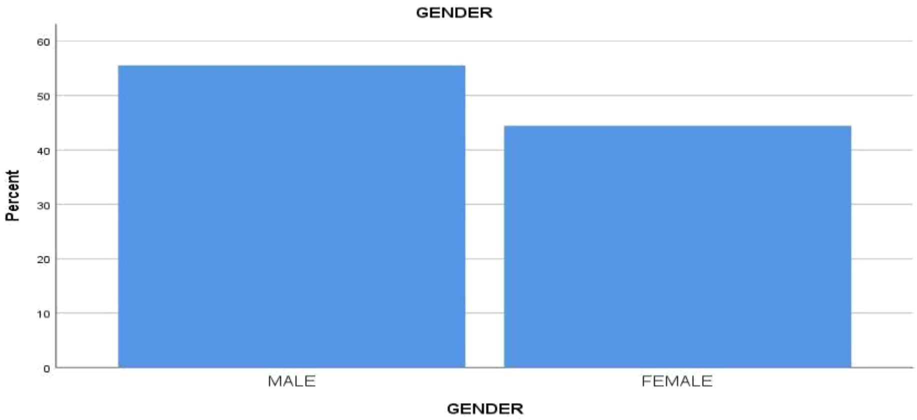


Figure 50: Gender response rate

The bar graph shows both males and females based on their gender that participated in the study and indicated that the current method used in Namibia is a traditional manual system that do all public health institutions in Namibia to access, receive, exchange and communicate disease surveillance data among public health institutions in Namibia. The percentage of male was 55% and the percentage of females was 45%.

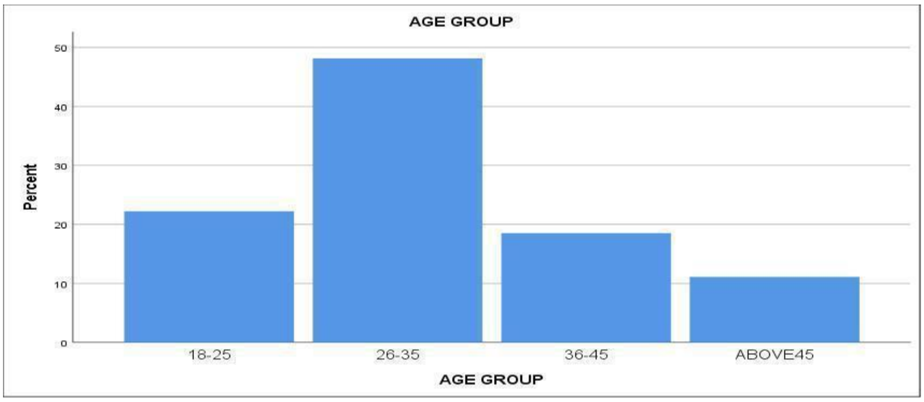


Figure 51: Age group response rate

The bar graph shows the participants' age groups: between 18-25 years, the age group between 26-35 years, the age group between 36-45 years and the age group above 45 years. The percentage of age group between 18-25 years was 23%, the percentage age group between 26-35 years was 48%, the percentage age group between 36-45 years was 15%, and the percentage age group above 45 years was 12%.

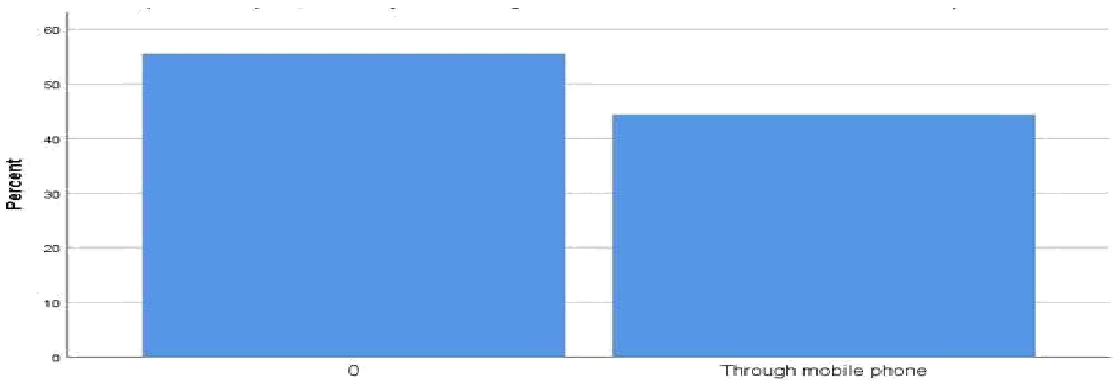


Figure 52: Exchange of disease surveillance data

The bar graph shows how public health institutions in Namibia exchange, receive, access and communicate disease surveillance data with other public hospitals through traditional methods of communication such as circulars, flyers, pamphlets. Majority of the participants indicated that they prefer accessing, receiving, exchanging and communicating their disease surveillance data through mobile technology platform. The zero on the bar graph represents 55% of participants who indicated that the current methods used to exchange and communicate disease surveillance between public hospitals in Namibia is a manual paper based systems and through mobile phone on the bar graph represents 45% participants who indicated that they do not receive disease surveillance data through mobile phone among public hospitals in Namibia.

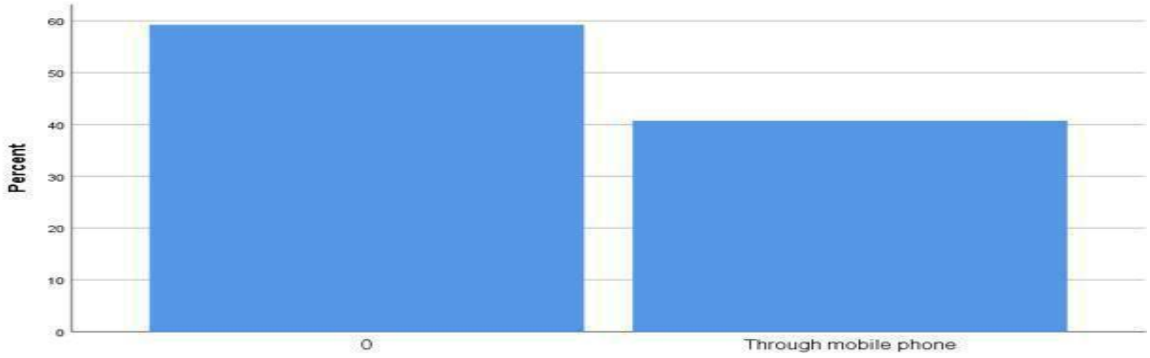


Figure 53: Accessing of disease surveillance data

The bar graph shows the current method the participants prefer to access, receive, exchange, and communicate disease surveillance data through mobile phone. Therefore, the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual system which is inappropriate when one public health institution wants to receive, access, communicate and exchange information from other heterogeneous health information systems. The zero on the bar graph represents 58%

participants who indicated that they access disease surveillance data through a manual paper based systems and through mobile phone on the bar graph represents 40% of participants who indicated that they do not access disease surveillance data through mobile phone between hospitals in Namibia.

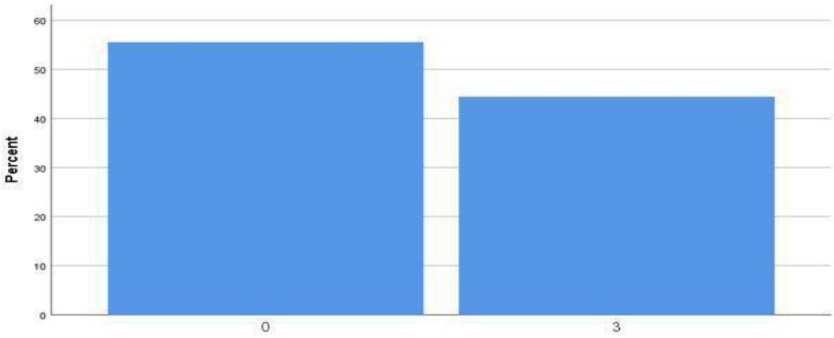


Figure 54: Type of disease surveillance data

The bar graph shows the type of disease surveillance data that public health institutions receive, access, exchange and communicate from other public health institutions which is a manual process which cause delay in quick and fast decision making when one public hospital or public health institution want to receive, access, communicate and exchange the same real time disease surveillance data to other public health institutions. The zero on the bar graph represents 56% of participants who indicated that the type of disease surveillance data the receive among public hospitals were sentinel surveillance, accelerated Disease control - national active and national Passive. The 3 on the bar graph represents 43% of participants who indicated that public hospitals in Namibia exchange and communicate disease surveillance data through manual paper based systems.

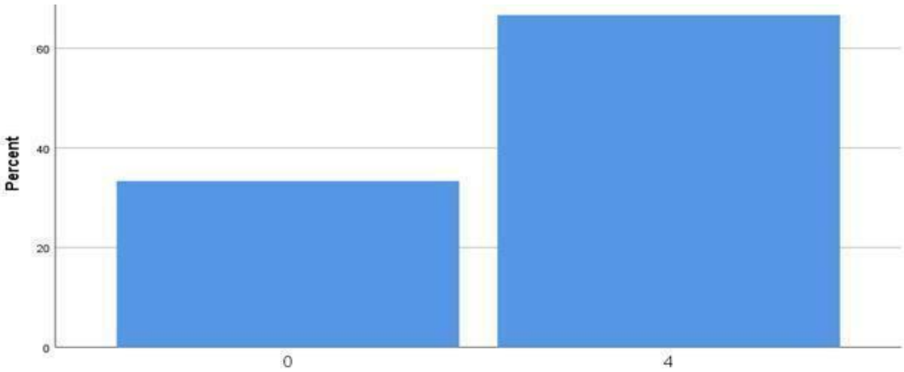


Figure 55: Preference to receive disease surveillance data

The bar graph shows the majority of participants who indicated that they preferred receiving, accessing, exchanging and communicating disease surveillance data from one public health institutions to the other public health institutions. The zero on the bar graph represents 25% of participants who indicated that they prefer to exchange and communicate disease surveillance data through mobile phone and the 4 on the bar graph represents 65% who indicated that the current methods used in Namibian public hospitals is manual paper based systems.

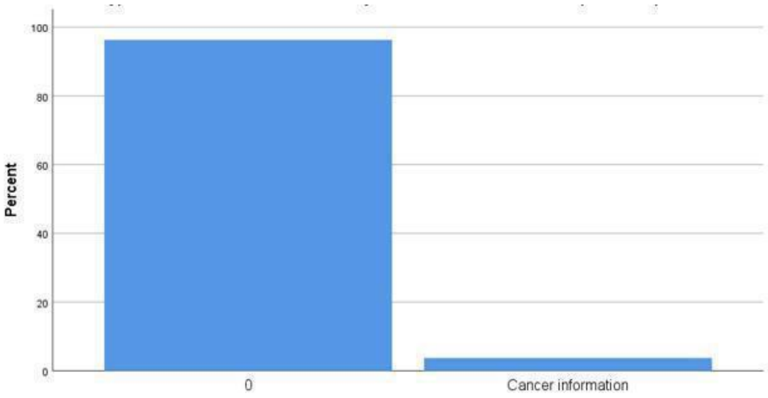


Figure 56: Type of disease surveillance data respondents want to receive

The bar graph shows the number of participants who indicated that the type of healthcare information they want to access, receive, exchange and communicate with other public hospital is disease surveillance data in addition cancer information. The zero on the bar graph represents 88% of participants who indicated that the type of disease surveillance data they receive were sentinel surveillance, accelerated disease Control - national Active and national passive. The cancer information on the bar graph represents 1% of participants who indicated that they receive cancer information through mobile phone.

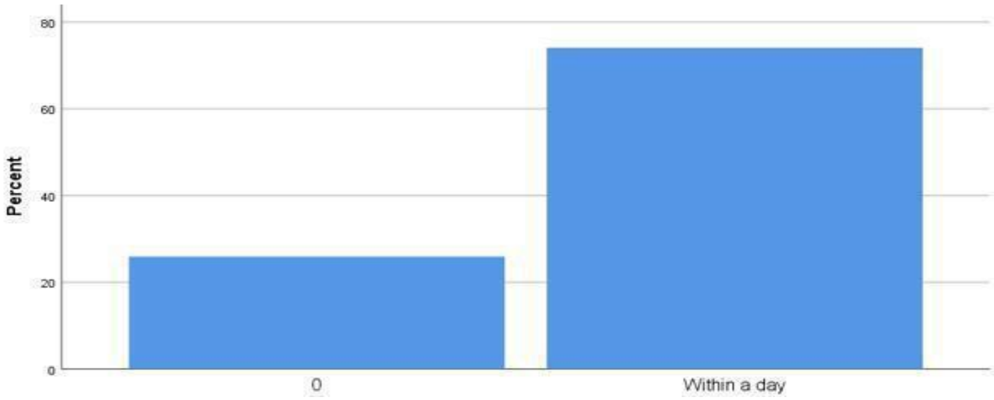


Figure 57: Duration it takes to receive disease surveillance data

The graph shows the number of participants who indicated that it takes many days to access, receive, communicate and exchange disease surveillance data through traditional methods of sharing information such circular, flyers and pamphlet and through physically visiting a health facility. The zero on the bar graph represents 24% of participants who indicated that it takes on average a month to receive disease surveillance data among public hospitals in Namibia and within a day on the bar graph represents 70% of participants who indicated that it doesn't take within a day to receive disease surveillance data between public hospitals in Namibia.

5.3 CDC, MoHSS, Public hospitals Interview Findings

The researcher had an opportunity to interview 1 Chief computer technician, 4 Technicians, 2 system administrators, 1 Senior system administrator, 2 Chief system administrators, 1 Chief analyst programmer, 2 Analyst programmers, 1 Senior Analyst programmer, 1 Data analyst(HIS), 1 HIS technical advisor, 1 National surveillance officer, 1 Senior health programmer, 6 Registered nurses, 1 Doctor,1 Student doctor, 3 Student nurses,2 NIP Technicians (laboratory and 3 Enrolled nurses at two hospitals in the Khomas region, namely Katutura State Hospital, CDC, Windhoek Central Hospital and the MoHSS. A total of 18 health professionals from Katutura State Hospital and Windhoek Central Hospital and 16 IT professionals from the MoHSS participated in the study. The findings of these interviews are as follows:

5.4 The current methods used to exchange disease surveillance in Namibia

The participants indicated that currently in every district public hospital and central hospital there is a department/center of disease control (what we call CDC) this specific center is the one responsible for collection and diseases surveillance information. For instance, an incidence of a communicable disease is established in a specific hospital at an infectious department, it is a responsibility of a supervisor/head of that department to make sure this new case is reported at CDC and hospital management is informed too. It is after then that CDC of such hospital information/ convey this case to a regional level (to the regional health director) who then has to see that this detail has reached the headquarter (minister of health). All this can be communicated via mails, and/or telephonically. If it is cases of highest morbidities and mortalities then the highest level should foresee to it that this information is published either through mass medias, reports, information leaflets or via other means of communication like radios to inform public about danger of disease, ways how they are spread and what are signs and symptoms and how to prevent self from contacting it and where to seeks help. Furthermore, the current communication method in use is the paper-based; the electronic methods are only used between offices. Healthcare providers record in a patient’s passport or use a referral letter to the receiving facility and through written memos from HIS district office (mostly electronic).

The participant indicated that disease surveillances data is communicated and exchanged through emails, sending technicians with a file to the regions and import the file into the system, usage of USB with a file or alternatively, the whole computer from the regions are send to Windhoek and also the current methods used to communicate or exchange data to other health facilities is through a formal letter request signed through the right channel until it reach the right department.

Some participants indicated that the current methods used to communicate and exchange disease surveillance information is through case notification forms, disease notification forms and reports (monthly, weekly). Furthermore, some participants indicated that the method used to communicate and exchange disease surveillances information is through Leaflets, handouts, posters, local press, televisions, media, advertising, presentations slides. Some participants indicated that they communicated and exchanged disease surveillances data through medical superintended and MoHSS public relation office. The participants indicated that the current methods used to communicate and exchange disease surveillance data to one another public hospital or MoHSS is through email, use of USB and send the information. However, in case of emergency, phone calls are used to communicate the information.

Furthermore, the participants stated that these are the only methods currently available to exchange and communicate disease surveillance data. The other methods used to communicate and exchange disease surveillance information is through verbal (supervisory visits) and also through circulars or fax. The participants stated that the fast methods, e.g.

emails and cellphone calls, can make information to reach within minutes. In addition, the participants also indicated that every hospital has government paid telephones/calls. With the circulars they are recorded for record keeping purpose and are marked the time of receiving them for people not to say that they are not aware of a certain outbreak. The participants indicated that the current methods to communicate and exchange disease surveillance data were through patient referring letters.

5.5 The current methods used to access disease surveillance data in Namibia

The participants indicated that all facilities report on a vertical approach, clinics report to the district primary care office then regional and finally national level. In the same vein, hospitals report to the matrons' office then regional and finally national level. The district or regional programme administrators then notify hospitals about diseases of concerns depending on weekly reports. There is hardly a hospital to hospital disease surveillance communication. Furthermore, the participants stated that the current methods used to receive data are through the surveillance system or through meetings where disease data is shared.

The participants indicated that information sharing in disease surveillance system is being done through daily basis reports (if possible/suspected case is established from clinic level / from health care centers that are in remote areas, they then do referrals of patients (with a suspected case) to the district hospital for case/outbreak investigation. District hospital then reports to region upon confirmatory of a new case. Some participants indicated that, it depends on the type of information send on a daily basis or other send on a weekly/monthly basis. Some of the data takes a long time for the lack of training on the importance of frequent reporting /or on the system of reporting. Some participants indicated that, they receive disease surveillance data through pamphlets and memorandum. Furthermore, participants indicated that disease surveillances information is received through PS and medical superintended office. The participants indicated that the people that work in health information system office communicate with each other and each person will that take information to their respective departments and if there is a need for assistance then they will choose who should go**.** Moreover, these are the only methods currently availability to communicate and exchange disease surveillance data. The participants indicated that they receive disease surveillance data or information through regional circulars/memos, telephonically, verbally (during workshops, in-service training or supervisory support visit and through DHIS-2 which is only accessible to view only information for a specific hospital and users are not able to view information for another public hospital in another region. Some participants stated they received disease surveillance data through feedback by workshops and introduction of system applications.

5.6 The challenges on the current DHIS-2 system in Namibia

The participants indicated that, normally the person-in-charge of a facility is responsible for weekly summaries of all disease cases treated and forward them to the district primary health care (PHC) supervisor who scrutinises those weekly summaries, measure disease trends and conclude if there is shift in cases. If healthcare providers notice any unusual increase in rare conditions they inform the district and regional office immediately at any time of the week. They do not wait until the end of the week to report based on summaries. The participants stated that it has a process e.g. if there is an outbreak in Windhoek, the Ministry of Health and Social Services has to convey the message to its regional offices. It takes long, an average of a month. Contagious disease leads the ministry to take long for preparation of PPE (Personal Proctection Equipment) which are costly and not budgeted for at the time of a particular outbreaks occurrence. It takes long, as it goes under various steps before the action is taken. Some participants indicated that it takes seconds when disease surveillance data are send via phone calls, takes minutes when disease surveillance data are send through emails and hours (paperwork), that is sometimes is being send with a car. The participants further indicated that for urgent intervention since it is a communicable disease matter. Telephonically takes a short time - Papers take hours, that sometimes there are no resources e.g. ink, printer slow, or there is no transport available to take to the respective facility and network unavailability delays emails/DHIS-2.DHIS-2 is dealing with one disease only (malaria). Some clinics in remote areas are not given due to unavailability of network. One officer in a certain health facility is not able to see the information entered from another hospital in addition, environmental office cannot enter active case information from casualty his DHIS-2 can only accept data from his/her surveillance. The participants engaged stated that it may take few minutes +5-10 minutes if there no network problem through email and also it may take hours or days through a letter. Furthermore, it takes long due to internet problems and also it may take long due to short of resources such as ink, or no printing paper. The participants indicated that as soon as the confirmed case is recorded in a hospital, then no need for this information to be contained within one hospital but to be conveyed to other hospitals and to start identifying and evaluating people who have been exposed to infection (contacts). The participants indicated that it is the way the system was set up but there are no limitations to prevent immediate communications to the relevant offices. Hospital to hospital communication mainly only happen for referral purposes but not for reporting. The participants indicated that disease surveillances data takes within a short period of time (approximately 1-2 days after disease confirmation).

5.7 The solution to the current health information systems in Namibia

The participants indicated that there is a need to come up with a real-time electronic communication network whereby hospitals can access reports without delays. However, there are safety concerns regarding the electronics in facilities since most facilities in the country have been broken into several times and a numerous valuable items such as office computers and TVs for patients have been stolen and never recovered. Furthermore, the lack of access to stable internet connection countrywide is a limitation to this approach. There should be a formal platform for the facilities to facilitate communications in sharing with each other on disease outbreaks or prevalence. The government could embark on a modern affordable portable computer such as tablets which have some useful programmes that can facilitate inter-facility communications. But they will also need to improve the infrastructures for example secure storage of the electronics at the end of the day and network and also system should have features to integrate. The participants indicated that the Ministry of Health and Social Services, CDC and public hospital should set up an integrated system that would enable health professionals to access and exchange disease surveillance information timely. The participants during the semi-structured interview conducted, indicated that all hospitals need to be provided with the DHIS-2 tracker system for all communicable disease unlike the recent one that only tackle malaria. The participants also indicated that, at least government should put aside amounts to pay for telephones for fast communications as well as on-going training (upgrading) of personnel running this surveillance issues. Government must employ for surveillance not to be overloaded with work e.g. 10 villages with one environmental health practitioner. The government has to apply for donation for easy management of accurate conditions. The participants stated that all public hospitals should have access to internet such as WI-FI which makes work easier. In addition, public hospitals should have enough resources such as ink paper and fax machine working, supervisors should share all the necessary information on time such feedback about disease surveillance and also all public hospitals should have local person for disease surveillance support. The participants indicated that public hospitals should have access to the internet so that they can be communicating with each other. Through this way, health professionals can exchange knowledge easily and also the data storing system in the public hospitals also needs to be upgraded so that the health professionals can have access to previous and current cases readily available. Some public hospitals need internet access and extra computers to access information more easily. Moreover, at least for the full mandates to be given to regional hospital or even to district hospitals so they can have authority to release information into public on time regarding diseases outbreaks or new cases of communicable diseases without awaiting cases to be reported first at headquarter that will then release to public. The surveillance system should be frequently evaluated and monitored to ensure that it captures all the relevant information. The participants indicated that the use of meetings takes long to convey information; therefore, the ministry should equip hospitals /clinics with internet connection and ensures that it is in working condition to ensure effective communication.

5.8 Namibia institute of pathology interview findings

A total of two NIP laboratory technicians were interviewed indicated that the institution has a lab information system with modules based on the operation of the organisation and user role and responsibilities which act almost like ERP. The institution has 40 labs using the same information e.g. doctor portal which enable patients to receive real-time results and also sms printer which is used at the clinic level. The participants highlighted that despite lab information systems in place the challenge remains in the health sector in Namibia simply because we do not have one health record for instance if a patient is based in Windhoek now his/her health record might be with a doctor in Windhoek hence if a patient moves to another region than her health record is lost or no references on the previous condition of the patients. Hence is important to have a semantic system to aggregate data from remote systems operating in one health sector. The participant also advised the study to look at

how private hospitals in Namibia manage their health-related data. “When doing integration consider a data policy to govern data obtained from heterogeneous health information silo systems in Namibia public hospitals.” “Consider the structured data and unstructured data when integrating data from heterogeneous systems.”

5.9 ICT staffs interview findings

A total of 16 IT personnel were interviewed which in the ministry of health and social services. The system administrator (MoHSS) indicated the methods used in the MoHSS to access and receive health related data within the ministry IT department. The system administrator stated that the current method used to access and communicate health related data is through login the system and access files in the system. Login the system remotely and access the data, no interface system no integrated system in the Ministry of Health and Social Services at the present moments. The IT personal are using the above mention methods because there is no other option due to the fact that it is the only current method available at the moment. The current methods used to communicate and exchange disease surveillance data is through emails, telephone call, two Whapp groups used both locally, regional and nationally. The Ministry of Health and Social Services has 7 +4 IT personnel at the head office and 4 at central hospital. The system administrator suggested that the ministry should implement integrated system that would allow users to access health related data at one central point. Another way of accessing health systems or data is through network system, the ministry has wide area network as long as the user is connected to the ministry network they can access information shared on the network. DHIS2 is only limited and accessible to certain users and it only shows information about malaria. It takes about 24 hours or two days on average to access information from the regional offices because health related information is send to the region through courier which means by car as means of transportation. The system administrator (MoHSS) indicated the methods used in the MoHSS to access and receive health related data within the ministry IT department is through whapp groups and email group. The current method used to access health related data is through remote desk to access health related information deployed in different department of the Ministry of Health and Social Services. The ministry uses email, telephone and two WhatsApp groups using portable devices such as memory stick to get files from one system to the other, user have to go physically with a memory stick and import the data manually from a remote system. Other health facilities such as clinics are not on the network that makes it difficult to access information from other health facilities within the ministry, regionally and nationally.

The challenge they have is lack of integration stand-alone systems as the systems are developed in different format and have different data structure. It takes about 24 hours or two days on average to access information from the regional offices as health related information is send to the region through courier which means by car as means of transportation. The other method used by the IT personnel to communicate and exchange health data is through VPN (virtual private network) which seems to be only limited within the same network, other users that are not part of the network would not see what is happening to other department. The system administrator (MoHSS) indicated that the methods used in the MoHSS to access and receive health related data within the ministry IT department is through whapp groups and email group. The current methods used to access health data from remote system is through DHIS2 and master facility list which cannot be accessed by all users, only certain users can access such system there is a certain module which do not integrated silo systems. The current methods used to communicate are through emails, telephone, no integrated system at the present moment. The current method used is the only method available at the moment, using email, telephone calls, two whapp groups used nationally and regional to communicate health data is accessed through DHIS2 and master facility list has a module to show health data related. The users go physically to remote systems and access information they want or login on the network system and access health data but some systems administrators have no access to such systems, there is a duplicate of systems at the present moment. The system administrator suggested that all systems should be integrated in order to share data with each at one central point. Every system is accessible to certain individuals but some other users cannot see what is happening to the other department within the same ministry. This is only the method we have to access system through the network which is only accessible to certain individuals. The ministry has what we call application programming interface system which is not integrated and only certain individuals can get information from such systems. It takes about 24 hours or two days on average to access information from the regional offices since health related information is send to the region through courier which means by car as means of transportation.

What is happening in the Ministry of Health and Social Service in the head office in Windhoek other users based in the regional office, they cannot access such information only head office IT personnel's have access to certain information. The ministry has system duplicate; you may find one system has almost similar features with the other systems within the same environment. At the present moment the ministry proposed the E-health system which is not yet fully functional, in other words the Ministry of Health and Social Service at the present moment does not have integrated system or platform e.g. if a patient relocates and they lost their health passport than that means is difficult to track the patient medical history and thus the patients have to open a new file for treatment and eventually doctors will give new treatment for that specific patient. At the present moment what is happening in Ministry of Health and Social Services if a user wants health related information from silo systems, a user physically moving from one system to the other system to access information or important information. The system administrator suggested that every system be implemented in the Ministry of Health and Social Services, all communication between the stakeholders should come IT department before coming up with the system.

Merging all the databases will result in one integrated system. The Ministry of Health and Social Service has standalone systems, every department has its own systems which make it difficult to access data from other department, or region. Each department does not see what is happening in the other department within the same ministry. The present moment we do not have infrastructure to centralise systems as yet. The current methods used are email, telephone and whapp groups, but there is no platform for information sharing. What they do in Oshakati is different from what is happening in Windhoek. For the fact that they do not have integrated system, that is thus why we are doing it that way. The clinical information is not accessible in all the departments in the ministry departments. The system administrator suggests that having a technology platform to communicate and exchange disease surveillance data will be much faster to access the information and also there is a need of introducing integrated systems. Also to introduce the business intelligence tool which will allow users to access information they need. At the present moment, the ministry does not have a system catering for sharing data between systems; we do not share information from a system to a system. The current method used to exchange and communicate health related data is through email, telephone, whatapp groups for the department and also a help desk top system is used as means communication among IT staff. The method used to communicate such as email a user can easily access the information send right away. They do not share information with other systems, the current method is used only when importing a file manual from the system, currently we use this method because is the form we have. At the ministry level, we do not have access to different systems used in the ministry so the current method used to access data is through login in the system remotely and access such information but, we are limited to some systems. If a user wants information from the other systems, they request from that department for such information.

The 34 hospitals are connected with internet therefore; the method used to communicate with hospitals is through internet and use methods such as emails, whapp groups, and cellphone call. The ministry is using this method to communicate because it is the current method available at the present moment. They also use group email, where information is disseminated through intranet to communicate within the department but this is limited to other users in the region. These are the methods available to communicate with each other. Data is posted on the ministry website. The reasons why we have silo health information systems is because of lack of coordination, due to non- profit organisation is the biggest issues. HIS technical group has the responsibilities to decide which information should be shared among various departments in the ministry. No integration of health information system because the format is different due to the fact that systems are developed using different languages. The ministry also uses API –Application programming interface, but this system does not integrate disease surveillance data.

The ministry uses a web site to disseminate certain information. At the ministry level, they access health related information through the server but not everyone has access to the information. Login remotely and access data. At the ministry level, if you want to share something with other IT staff, we share it on the server, there is no platform used to access disease surveillance. The ministry has many stand-alone systems, we do not access all the systems and we do not know what is happening to other department. The ministry server at the head office is not accessible to the regional office, only people who work at the head office have access to systems whereby they remotely login to access systems. The availability of accessing information to users depends on the network in the region, regional office access health related information through the server but administrators in one regional office cannot access data from national office. At the ministry level, IT personnel at head office are the only ones who have access to login and access health related information. The ministry there has two methods to communicate health data through email, telephone call, whapp groups, service desk. The ministry should come up with a new technology platform in terms of sharing health data among various department, and regional office. The method used to communicate at the ministry level is through telephone call, text message, whapp groups; we do not have a system in place to share disease surveillance data.

The ministry uses these methods because this is the only method we have at the present moment. When communicating through email and whapp groups, the user will get the message right away. The ministry has many standalone systems which do not communicate and work in isolation. The IT staff uses telephone, email, whapp groups for all IT personnel. At the ministry level, if a user wants information in the system, they login remotely access systems on the server if you are on the network system. The method used to communicate at the ministry level use phone call, email, whapp groups to communicate. This current method we use to communicate in case of emergency. At the ministry level we do not exchange information with other hospitals or other departments. The method we use to communicate; user can get the message depending on the availability of that person such as the national whapp groups. The E-health does not include all the aspects done in the hospital and at the regional level. The current method used to communicate and exchange health related information at the ministry level is that we use help desk system, emails, whapp group, phone call, fax, national whapp groups. The help desk system has a limitation because it is only accessible at the head office but regional offices do not have access to what is happening at the head office, and also we do not have access to other systems within the ministry. The current method used to communicate is through network system with each other and this is only limited to users that are on the network not everyone accesses such information. They do not have systems that are interfaced in order to exchange and communicate health data. At the ministry level, we do not have infrastructures in place for health data integration. The current method used at the ministry level to share health related information is through email, telephone, whapp groups, circular. With the current method used for communication it also depends on the availability of the user.

The other method we use at the ministry is through service desk system for example if a user request specific services, you can be assisted. The ministry has system network, so most systems are on a network and users can use IP address to login remotely, and also use URL for web based application. The ministries of health systems are on the server as long as you have credentials to login if the system is on the network. The ministry is using this method because those are recommended methods available so far. The IT department share health related information through the network systems, so they created a network folder which is used to share health related information from one IT staff to the other. The health related information shared in the network folder can easily be accessed, the information shared in the folder but only limited to people on the networks. E-health system should consider integration of systems. The ministry has 3 analyst programmers. At the ministry level the method used to communicate and exchange health related data every user login access the system remotely and get information you need. The current methods used to communicate and exchange they make use of email, telephone call, fax, IT use server and access the information is shared through server remotely. At the ministry level, at the present moment, not all the systems are web based systems, some desk application systems which are deployed at different departments in the ministry. Only some people have access to the server which means there is limitation of information to certain people working within the same ministry that is why individuals from different department request information. It is limited to certain people who have access to the server where health information systems are deployed. They have P-track system.

The other method used you have to move from one system to the other system, to access health related data and some systems are desktop application which make it difficult to access health related information. They do not have a health information system that can exchange and communicate disease surveillance data in real time at the present moment. They have a system that identify occurrence of disease, master facility list system but the system is not integrated to share disease surveillance data in real time. The current system used is time consuming due to the fact that a user has to move from one system to the other system and does not have access to all the systems in the ministry. The ministry has two programmers. At the present moment the current method used to communicate at the ministry level is through email, phone call, help desk system, intranet such email group. The reason why we use this method is because this is the only current method available at the moment.

The current systems are standalone, some systems are not accessible to everyone, we have p-track system which is a system used to track the transmission between baby to mother during birth of a child. At regional level they do not access what is happening at the head office. At the moment if you need health related information you have to go from one system to the other system which is time consuming so a user has to physically go to access information they need. They do not have integrated systems that exchange disease surveillance data in the Namibian health sector, everything is currently done manually and users do not receive real time data. The current method used to communicate disease surveillance data is through email, telephone call, help desk system.

At the ministry level we do not integrated health information systems to exchange disease surveillance system. What happens at the department, we do not communicate with other departments and other regional offices, what happen is that, a user has to send pc to Windhoek to upload data. The ministry has a p-track system as a prevention mother to baby, if the mother delivery the system is used in terms of monitoring and evaluation. The method used by the ministry of health and social services to communicate and exchange disease surveillance data is through whapp groups, email and phone call. The DHIS2 and p-track they system have some features that are linked which is used to record issues and act as a help desk system, track how many health related issues were reported.

The Ministry of Health and Social Services has many systems such as e-death system which are not interlinked, currently the ministry is working on the idea of linking DHIS2 and the p-track system. The e-health is to be integrated at data level. If you want to access data from p-track system, the users have to login remotely or go physical to the other HIS to access such information because it is a web based system. It takes long if a user has to go physically to access data, short time when a user login remotely. The DHIS2 and P-track system can generate two different reports of which a user has to compare the two results separately. DHIS2 is used to report cases of disease report in the country while P-track system is for prevention of mother child transmission. The Ministry of Health and Social Services has no health integration system, so if a user wants data from one system, you have to request the data from other departments manually or physically, so you do not have access to DHIS2. So someone who works with p-track system has no access to DHIS2, and someone need data from p-track they request data from the people who are responsible for that system. The ministry has 3 data analyst (HIS).

5.10 The current status of HIS in Namibia

In the Namibian health environment, there is no framework to enable interoperability but is not fully implemented and it took the ministry 5 years and the ministry is still struggling to aggregate data from remote silo systems which means as it stands no integration of system. The HIS technical advisor stated that they have many standalone systems which work in isolation and they do not communicate with each other to share health related information with each other. These types of systems include lab-medi-tech, p-track system, ART-EMPS-HCT, EID, pharmancy – EDT, NIP-lab, aggregated system, support system, HR, financial and DHIS2. Despite many standalone systems in place, the fact remains that these systems are not integrated, they do not communicate and exchange health related data between other information systems within the same ministry locally, regionally and nationally

5.11 Division of epidemiology (MoHSS)

The department deal with investigation of disease occurrence based on rapid or how emergency is the disease. The current methods used by the Ministry of Health and Social Services to communicate to communicate and exchange health related information is through emails, telephone, whapp groups or you can take picture of something and send it to whoever needs it and also monthly meetings. The other method used to share disease surveillance data is through filling what we call an investigation case form, sharing disease surveillance data there is a form to be completed manually which is completed in one facility and send to the district office and from the district office the than final the form will send to the again to the head office and under the division of epidemiology where disease surveillance is kept by surveillance focal person. The present moment the Ministry of Health and Social Service does not have a health integrated system for disease surveillance data. With the DHIS2, you cannot view data entered from the region and people and the regional people will not view data entered by another region. In other words, there is no platform to exchange and communicate disease surveillance data in real time. The department of Epidemiology in the Ministry of Health and Social Services usually receives disease surveillance data from district office and regional office before the 5th of every month. All activities done over a month and all disease surveillance data is reported weekly, and monthly and at the same time the reports reported monthly and weekly are different not the same reports. It takes time to capture data from the health facilities manually, no access to other silo systems, all systems we have do not communicate with each other. We have duplicate systems. The Ministry of Health and Social Services does not have a platform that interlink the hospitals silo systems with ministry systems, we do not have a system that track contagious disease system as it stands, the ministry or hospitals relay on the person in the hospital or the ministry.

Communicable diseases are the most common cause of illness, disability and death in Namibia. While these diseases present a large threat to the well-being of the Namibian communities, there are well- known interventions that are available for controlling and preventing them. Namibia has a relatively efficient surveillance and emergency preparedness and response (EPR) system in place. Despite this, the country experienced a number of epidemics such as Cholera, Crimean Congo Haemorrhagic Fever, Influenza H1N1 (2009), Measles, Meningococcal Meningitis, Polio and Rift Valley Fever, just to mention a few. In order to strengthen disease surveillance in the country, the Ministry of Health and Social Services has adopted and prioritised an integrated disease surveillance and response strategy (IDSR). The goal of IDSR is to improve the ability of districts to detect and respond to diseases, conditions and events that cause high levels of morbidity, mortality and disability in the district's catchment area. This is the department in the Ministry of Health and Social Services that deals with disease surveillance data which includes different levels.

5.12 Disease surveillance data exchange at regional level

What happens in terms of exchanging disease surveillance data is that, there is no mandate to declare the outbreak of a disease in the region. Monthly meeting and CDC manager facilitates meetings and share information with other colleagues. They collect malaria statistics and they collect data through other staffs that attend regional meetings. They do not get real data; data are collected through a manual process through an investigation case form for malaria.

The process of communicating and exchanging disease surveillance data is a process that involves 5 levels of reporting: community level, health facility level, district level, regional level, and national level which includes different offices such 1 administrative office (IDSR) integrated disease surveillance and response. IDSR is the one who is responsible to report disease surveillance data who receive data every Monday and submit data to the world health organisation and other development partners every Tuesday of the week. All the 35 district hospitals have surveillance offices responsible for facilitating process of ensuring that disease surveillance data pass all the 5 levels of reporting disease surveillance data. Also, all the 14 regions have surveillance offices responsible for reporting disease surveillance data to right channels and management health information offices.

5.13 Four levels of reporting disease surveillance data at MoHSS

5.13.1 Community level

If the community, the health worker detects an incident of epidemic, they complete an investigation case form and send it to the health facility for further identification. Diseases are then classified into different categories called case definition, depending on the symptoms of that particular disease. Then doctors would suggest that it is a known or unknown disease identified. The communicate health worker in the field can gather disease surveillance data and send it to the intermediate hospitals such as Rundu Hospitals, Oshakati Hospital, Katutura Hospital and Central Hospital and at each intermediate hospital there is 1 surveillance office who is responsible for completing an investigation case form and send it to the next level.

5.13.2 Health facility level

In each health facility, there is a disease surveillance office responsible for receiving and sending disease surveillance data to the district office through completing a manual form process.

5.13.3 District level

The district level there is a disease surveillance office responsible for receiving disease surveillance data from the health facility and can send such information to the head office through completing an investigation case form.

5.13.4 National level

The national level receives disease surveillance data through the district level and the national level would send this information to the laboratory for testing purposes to identify what type of the disease is affecting a particular region. The disease surveillance office has to go physically to collect investigation case form from the laboratory and eventually send the results to top management to declare that particular epidemic officially on media such as TV or newspaper. So, the process does not end only at national level, but it further proceeds to the administrative office responsible for managing the integrated disease surveillance and responses system which is in excel format and report all the disease surveillance data weekly, monthly, quarterly, yearly.

Also every Monday, disease surveillance data is received from all the four levels of reporting disease surveillance data and the submission of disease surveillance data is submitted to the world health organisation and development partners every Tuesday on the weekly basis. The national surveillance office is responsible for preparing the official letter to report disease surveillance data. The method used to communicate disease surveillance data is through excel spreadsheet of IDSR which is called integrated disease surveillance and response. Furthermore, excel file would be send to the relevant authority through email. Still we do not have a web based system to report cases of diseases. As a process from intermediate hospital, disease surveillance data is captured then send to regional office from the regional office information is send to the district office then send to the national office from the national office information. It is further send to the WHO and development partners as well as to top management or to the highest authority. So it does not end at the national level it goes to management such as permanent secretary, inform development partners and as national surveillance office we prepare official letters to the management as form of reporting disease surveillance data. Symphonic surveillance office helps to detect a particular disease. The doctors send an investigation case form to the laboratory for testing which disease is identified

The current method used to communicate health related information among different hospitals and within the hospitals is through land line call or through booking office. So, if a nurse wants to communicate with the doctor what happens is that, a nurse in ward has to complete a book manually and wait for the doctor to come in and pass the book to the doctor who will then prescribe the medication to the patient. If a nurse needs to transfer a patient from one floor to the other, the nurse will call and send the patient to the other department or the nurse will go physically to that department to get the information they need. If you want to communicate health related information, you need to go through ward matron, or hospital matron. The other method of communication is through whatsapp groups which means each ward has a whatsapp groups which is used as means of communication among nurses between two wards. The current method used to communicate among nurses in the hospital is through telephone call there is no technology used to communicate apart from land line and switch board, in case of emergency what happen nurses in duty can call the doctor.

If a nurse needs information from one ward to the other they usually go physically to that department and get the information. We do not have technology in place to communicate health related information. In the absent of the doctor, we usually wait for the doctors to come and see the patient first. The 3 nurses stated that method they use in the hospital is through telephone call, land line phone, with other hospitals and within different wards in the hospitals. They also use written information such as circulars as a method of communication between different hospitals and among different wards within the hospital setup. At the present moment we do not have a technology platform used as means of communication platform between nurses and doctors, the only means used is through telephone or a nurse has to go physical from one ward to the other ward. They use memorandum such as circular, or make copy from the circular and distribute it to other nurses in different wards. Email is used by administrative office and top management, internal circular or external circular. In case of other hospitals, you can also call nurses that are on duty, regarding email, not all the nurses have access to email on the office of medical office have email access and fax. Hospitals send community health workers in the field to capture data on written books. At the ward level, nurses can go physically if they need anything related to healthcare from one ward to other wards. Administration office has different communication methods wile wards communicate through telephonically. One registered nurse indicated that they communicate through telephone within both the hospital and wards. The other communication, if a nurse wants to access information from other hospitals we use phones, whatsapp groups, email, through a booking office, and this is the same method used to communicate to other hospitals. Another is written book, we use written paper such referral letters from one hospital, and through verbal communication. They do not have integrated system to exchange health related information.

One doctor indicated that they communicate through phone calls; doctors usually call the nurses. They do not fax because we do not fax have technology. Some hospitals do not have fax. Regional office also uses phone call. Another method is whatsapp group is to send information such as pictures x-ray information. Doctors are responsible to diagnose disease. The method used to communicate through radio room and through telephone call, other department can also and regional office can call other hospitals in region. Communicate through dashboard. Some doctors go physically to wards. The three student nurses indicated that the current method used to communicate information is through phone call such as land line with other hospitals and other departments. From the regional level they also use phone call to access health related information.

The hospital also makes use of porters and ward assistants to go physically from one department to the other within the hospitals. From other hospitals we use emails, fax, whatsapp groups and circular. In the theatre there is a need of a technological platform to interact with other hospitals as it stands, porters used to access information within the hospitals are extended to health centers across the country. One registered nurse indicated that the current method used in the hospital to communicate and exchange health related information is through phone call, verbal communication. The other method used is through sending porters to different wards to get you what you need; information about the patient demographic is communicated through telephonically. They also use whatsapp groups post documents such as circulars as method of communicating among staffs nationally and regionally. They proposed that there is a need for a centralised system to enable communication easier between staff, nationally and regionally. The two enrolled nurses indicated that the method used to communicate within the hospital set up; nurse can either call each other or can go from one ward to the other to access such information.

From the regional level we call directly to the hospitals, or fax can be used. They get information through NIP e.g. results. If a hospital matron needs health related information, it takes 3 hours to access such information, no integrated system to communicate such information. One registered nurse indicated that the method used to communicate among nurses and doctors through calling other hospitals or within the hospital, a nurse or doctor can go physically from one ward to the other ward. If other nurses in different wards is not picking up, you can go physically to that ward and get the information you need. No integrated system at the moment at the hospital level. One nurse engaged stated that they exchange and communicate disease surveillance data through telephone to call other wards. Sometimes you go physically to the wards and get the information. If you want to call regional hospital, you go through radio room and they put you through that specific hospital you need. One system analyst (HI) indicated that the current methods used to communicate and exchange health related information is through emails, information is extracted from information, district information system, request the data from the system by login remotely.

5.14 Conclusion

The study developed a framework for interoperability of HIS for-disease surveillance data through crowdsourcing adopting the HL7 standards. For proof of concept, this research developed a prototype to demonstrate how disease surveillance data can be integrated. The study suggested that future researchers should consider the aspects that were not covered in this research. So, since the study case was disease surveillance data in the health environment the research recommends future researchers should consider including other aspects about interoperability which specifies other health related information within Namibian health domains. The next chapter covers interlink protocol and its standards-based case studies.

CHAPTER 6: INTERLINK PROTOCOL AND ITS STANDARDS-BASED CASE STUDIES

6.1 Introduction

A protocol is the set of rules that governs the communication of two systems (Victoria, 1987). Moreover, the role of the protocols is to specify interactions between communicating entities (Kusniercyk, 2006). In this case, a protocol was developed as layer for communication purposes and as converter to aggregate disease surveillance data in Namibian public health institutions. This interlink protocol is based on JSON object format. In the Namibia health sector environment there is no known protocol as it stands that governs heterogeneous health information systems and the aggregation of disease surveillance data between the health institutions (Angula & Dlodlo, 2018), (Kalra & Blobel, 2007). Therefore, the study proposes a solution to address the challenge of a lack of exchanging and communicating disease surveillance data.

As applied to three case studies of the integration of hospital-to-hospital information, information from community health workers and information from crowdsourced data, this chapter explains the profiles, prototype development and evaluation of a semantic framework for disease surveillance data through adopting health standards in the Namibian environment. It describes the functionality and features of three different integrated profiles. The prototype is grounded on health standards, such as Health Level Seven (HL7), and Integrated Health Exchange (IHE). The Integrating the Healthcare Enterprise (IHE) advocates for the integration of distributed and heterogeneous health information systems. The IHE Information Technology Infrastructure framework houses profiles on how information is exchanged. The HL7 code from the HL7 technical report houses the structure of the messages sent between communicating entities. The messages have, as a basic minimum, the sending application, the sending facility, the receiving application and the receiving application with messages in the JSON format.

6.2 Related systems that enable semantic interoperability

The following are examples of related systems that enable semantic interoperability. These are the OpenEHR Archetypes Approach, Ontologies, Model-driven Engineering, Formal specifications, XLM and Jason.

A. The openEHR Archetypes Approach

According to Garde, Knaup, Hovenga, and Heard (2008), the openEHR archetypes approach enables syntactic interoperability and semantic interoperability to allow for the exchange of data from multiple information systems. The purpose of this approach is that it enables semantic interoperability among sources and receivers (Goh et al., 1999). This approach is not favourable for this research simply because of the uncoordinated efforts internationally and across health professions to match or aggregate heterogeneous systems currently. Further development of domain knowledge on archetypes is required.

B. Ontologies

Accordingly, the Enterprise Knowledge Diez (2006), states that ontology is a model that is capable of organizing structured and unstructured information through organisations, their properties and the way they relate to each other and organises the data in the same format. In other words, ontology consist of classes and properties. In addition, concepts are structured in taxonomy and relations are set as non-taxonomical connections (Goh et al., 1999). This approach is not favourable for this research simply because it doesn't clearly indicate how data is matched or aggregated among heterogeneous systems and because of the multiple interpretations of the same data.

C. Model-driven engineering (MDE)

According to Schmidt (2006), model-driven engineering technologies are capable of offering an approach which is promising in order to address the inability of third-generation languages to alleviate the complexity of platforms and express domain concepts effectively. This approach would also be lacking in enabling semantic interoperability since this research is an aggregation of data and not looking in depth at hardware or software.

D. Formal specification of context interchange

Based on Goh et al. (1999), context interchange is one of the strategies that represents a novel perspective which mediates data access where there are semantic conflicts among heterogeneous systems. This approach is not favourable simply because this is a developing research area and does not clearly indicate how data is matched or aggregated among heterogeneous systems.

E. Xml

According to Schmidt (2006), XML is a set of rules for ensuring that encoding documents in a format that can be both human-readable and machine-readable. XML has the following characteristics:

- XML is extensible.
- XML allows the creation of self- descriptive tags or language that suits an application.

These features of XML can be adopted for semantic operability save for the fact that it is heavy as compared to JSON (Schmidt, 2006).

F. Json

JSON or JavaScript Object Notation is a lightweight text-based open standard designed for human-readable data interchange (Schmidt, 2006). JSON has the following characteristics:

- It is used while writing JavaScript-based applications that includes browser extensions and websites.
- JSON format is used for serialising and transmitting structured data over network connections.
- It is primarily used to transmit data between a server and web applications.
- Web services and APIs use JSON format to provide public data. It can be used with modern programming languages.
- JSON is easy to read and write.

It is a lightweight text-based interchange format. JSON is very useful when developing a web application where fast, compact and convenient serialisation of data is required. However, its flexible nature is the very thing that makes it less suitable than XML for transferring data between separate systems or storing data that will be read by third parties.

- JSON is more compact and can be easily loaded in JavaScript.
- XML is stricter and has support for schemas and namespaces.

The lightweight feature of JSON and the fact that it is language-independent would be of benefit in this research for development of the protocol.

6.3 The general architecture of HIS data integration using the Interlink protocol

This research approaches this research from 3 case studies. These are case studies of distributed clinics/hospitals through patient demographics, community health workers (CHW) and crowdsourcing as shown in Figure 3. Users login onto their systems, be they desktop or mobile-based and capture disease surveillance data. The crowd-sourced disease surveillance data from the community members is captured via their cell-phones. The CHW capture disease surveillance data via their mobile devices. Distributed hospitals capture their data using whatever device including desktop, laptops, mobile devices, etc. The systems automatically generate JSON objects.

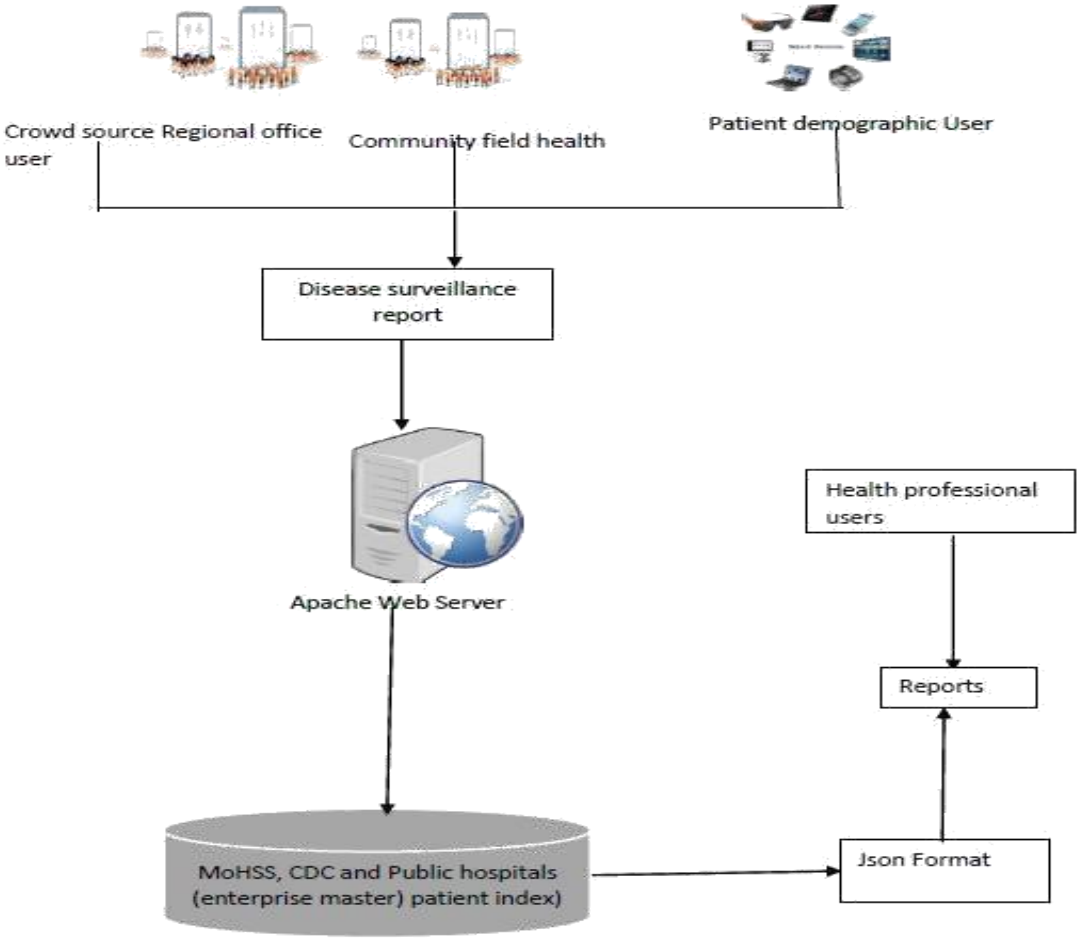


Figure 58: Architecture of the system

The Apache Web server in Figure 58 initiates the connection between the database and the web application. This database is the enterprise master patient index (EMPI) at the MoHSS that stores data from different heterogeneous health information system provided that the data is in JSON format. The health professional users will be able to view reports of statistics such as charts, graphs and so forth. Earlier we mentioned that the different HIS are heterogeneous in the sense that the data generated is not standard across all of them. Therefore, the JSON object is what creates this uniformity in the data, as shown in Figure. 63

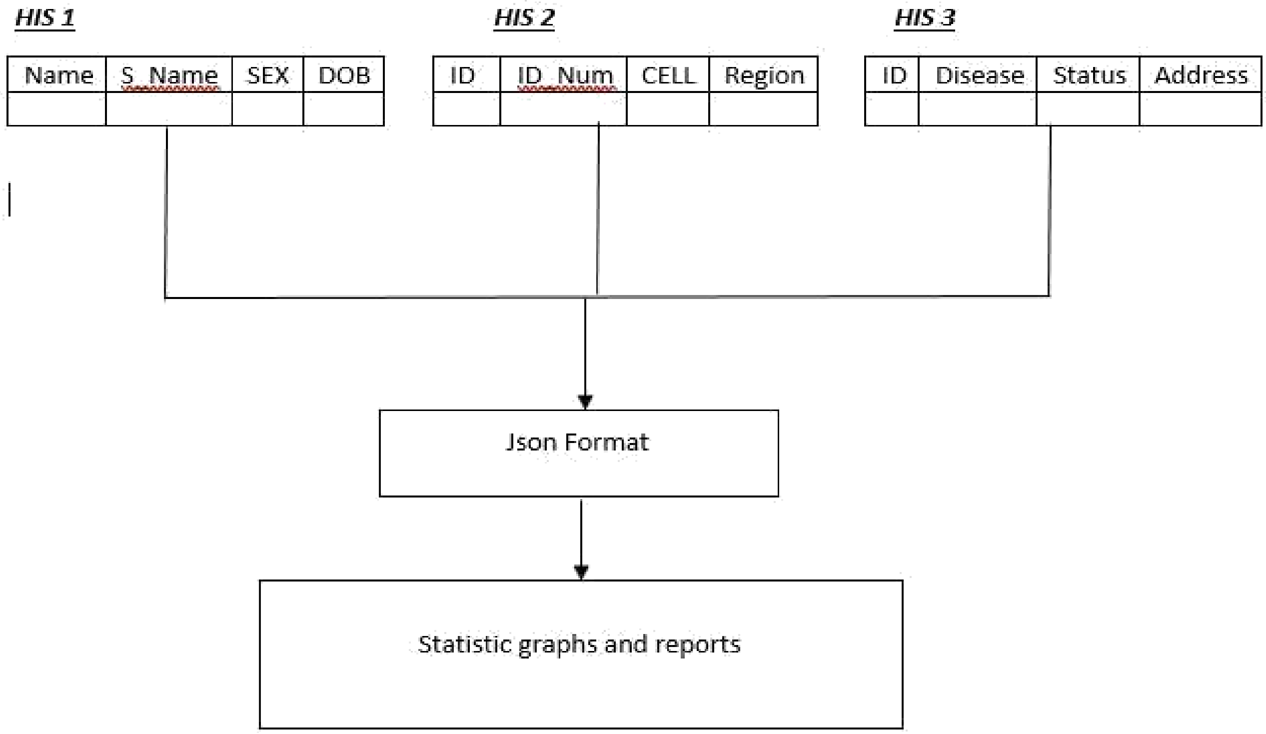


Figure 59: Uniform JSON interface

6.4 Interlink protocol

Data from different sources comes in the form of JSON files. As long as these files are in JSON format, the system will accept and produce disease surveillance statistics from them. Based on the information uploaded on the system, health professionals can view analysed data on the dashboard and can easily make quick decisions based on the information. The standard interface to enable aggregation of data is the rule of aggregating data and is coded as a layer to allow remote systems and DHIS-2 system to exchange disease surveillance data with each other in a meaningful manner. The aggregated data is used in the production of, for example, reports to be used in decision-making. The study therefore has identified a new protocol called interlink protocol in the Namibian public health sector that would act as converter to interpret data from different data sources. An example of the code for interlink protocol as used in a situation in which data from different hospitals is aggregated in JSON is as shown below in Figure 60.

```
{"source":{"name":"Grootfontein Hospital",
          "id": "0020",
          "type":"state hospital",
          "physical_address":"",
          "postal_address":"",
          "telephone":"",
          "fax":"064-344",
          "email":"",
          "town":"Windhoek",
          "region":"otjozondjupa"
          },

 "records":[
          {"category":"cholera",
           "id":"960619727272",
           "name":"Jeremiah Fonseca",
           "sex":"m",
           "dob":"19 June 1996",
           "telephone":"0813536",
           "town":"Grootfontein",
           "region":"Otjozondjupa",
           "email":"",
           "date":"12 January 2016",
           "description": "Patient tested negative for cholera"
```

```
        }
```

Figure 60: JSON object

This example protocol describes how the interlink protocol works. A HIS in the public hospital, CDC or MoHSS converts their disease surveillance data into JSON format. Data from different health institutions in Namibia can be translated into JSON format regardless of its data sources. That format is the JSON object. Figure 64 is an example of a JSON object for information generated from Grootfontein Hospital. It has records for different patients including the header with details of the particular hospital. This JSON object is in a standard format and so are the JSON objects for the other public health institutions.

6.5 An overview of case studies of the application of the interlink protocol

Figure 61 is the use-cases diagram. The crowd-source user, community health worker and patient demographic user can login to the system and submit reports and the system will generate JSON files automatically and integrate data from multiple heterogeneous health information systems which can be monitored and administered by the systems administrator at the head office in Windhoek. This administrator can be at the MoHSS or CDC. At the same time both users can terminate or logout from the systems.

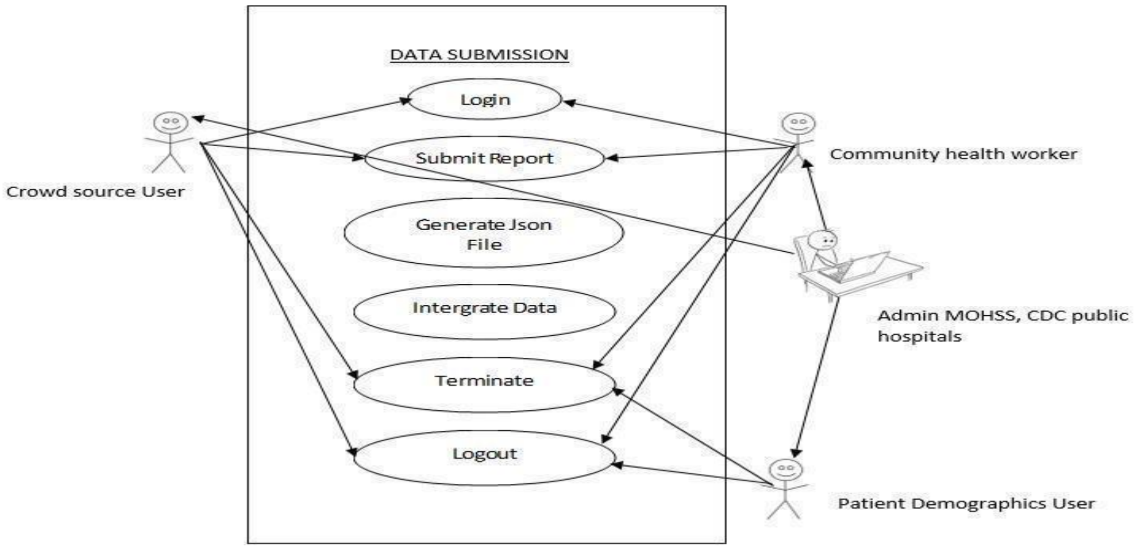


Figure 61: Use case diagram

The research follows 3 case studies: Crowdsourcing, Community Health workers, Exchange of data between hospitals.

6.6 Crowdsourcing case study

The following is a case study of the crowdsourced user that utilises the interlink protocol and the Retrieve Information for Display for the HL7 profile.

6.6.1 The systems architecture for crowd-sourced user

The systems architecture demonstrates the crowd-source user who is able to communicate and exchange disease surveillance data to the CDC, public hospitals and the MoHSS. This architecture demonstrates the interactions with the crowd-source users which enables communication and reporting disease surveillance occurrences in real time to the DHIS-2 in the public hospitals, the CDC and MoHSS via the Internet. The development of this platform is very useful for health surveillance because it has real-time information as diseases occur.

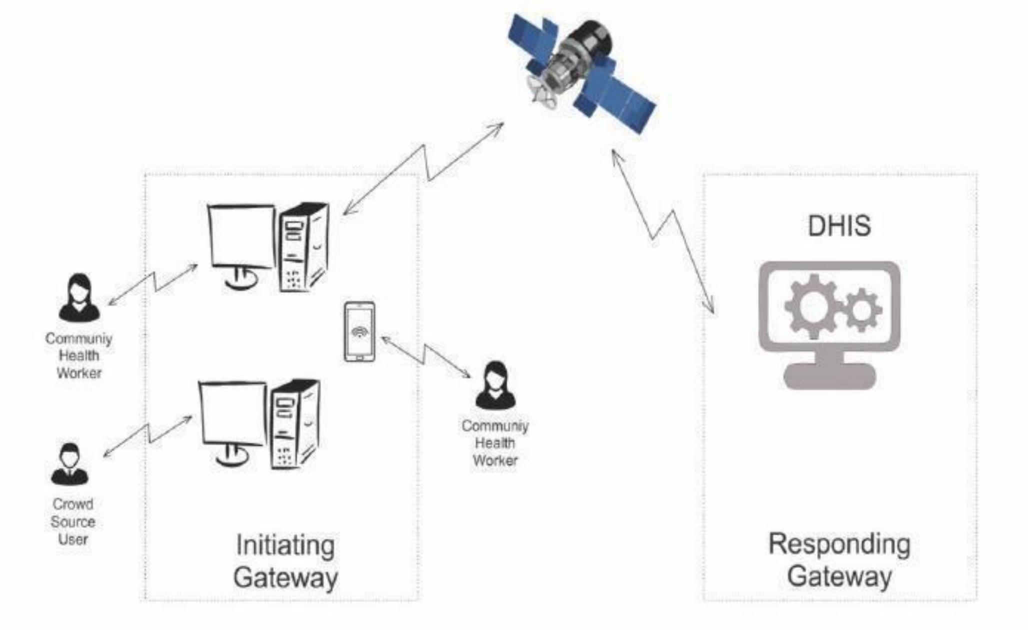


Figure 62: Architecture of system crowd-source users

A crowdsource user with a mobile device in hand can log onto the system and submit disease surveillance data in real-time to the regional DHIS which in turn submits to the national DHIS. The system will generate reports automatically based on the data uploaded. The regional and national health administrators have full control of the system.

6.6.2 Retrieve information for display profile

The Retrieve Information for Display (Figure 63) is an HL7 profile that enables access to information for visualization. The Retrieve Information for Display is defined as an integration profile that provides simple and rapid read-only access to patient-centric clinical information that is located outside the user’s current application but is important for better patient care. For example, access to lab reports from radiology department (https://wiki.ihe.net/index.php/Retrieve_Information_for_Display). It supports access to existing persistent documents in well-known presentation formats such as PDF, JPEG, etc. It also supports access to specific key patient-centric information such as, for example, allergies, current medications, summary of reports, etc. for presentation to a clinician. It complements workflows with access from within the users’ ‘n-screen workspace or application to a broad range of information.

The diagram below is an adaptation of the original Retrieve Information for Display profile to that for communication between the regional DHIS-2 and the national DHIS-2. The district-based DHIS-2 provides specific disease surveillance information in response to the request from a health administrator application that sits on the DHIS-2 in the MoHSS in a presentation-ready format. A regional DHIS-2 sits in each of the 14 regions of Namibia

At the same time a health administrator will be able to retrieve disease surveillance information from the main centralized DHIS-2s hosted at MoHSS, CDC or public hospitals. The addition to this profile from the crowdsource use perspective would be the data that the crowdsource users capture through their mobile devices and communicate to the regional DHIS-2.

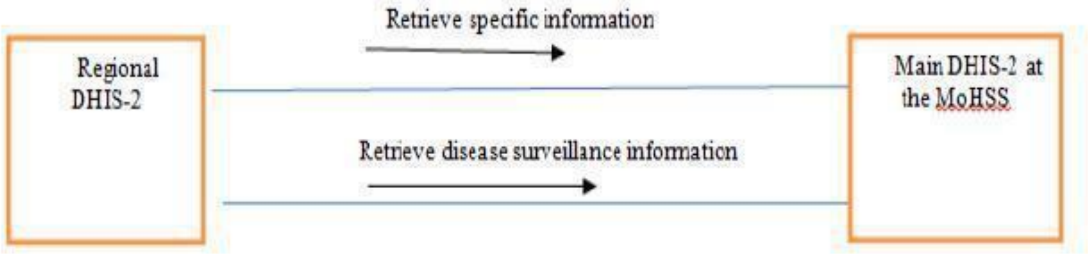


Figure 63: Retrieve information for display profile

6.7 Community health workers case study

The following is a case study of the community health worker user that utilises the interlink protocol and the IHE-profile: cross-community patient discovery (XCPD).

6.7.1 Community health workers

In Namibia, healthcare services are extended to communities through community health workers (CHW). Most CHW are sent to the field to educate and raise awareness of diseases in the communities. However, there is no platform for them to communicate the disease surveillance information to the regional and head offices in real-time.

Despite the MOHSS' efforts in the deployment of community health workers in the regions to educate and deliver health services to the communities in Namibia, the community health workers are the ones who gather disease surveillance information, which is time consuming. As a result, the government spends more money to cater for the community health workers who operate in the 14 regions of Namibia (CDC global health strategy, 2012–2015).

It is noted that Namibia's health domain does not have a framework that acts as guide to aggregate disease surveillance data to help the community health workers when collecting disease surveillance information in the 14 regions across the country. Thus there is a need to have a semantic interoperability framework that would enable a community health worker in the Namibian health domain of the MOHSS and public hospitals in Namibia to exchange and communicate disease surveillance information. The National Policy on Community Based Health Care Draft (2007), states that a community health worker is a member of the community who works on a volunteering basis or is remunerated by the community or society that 'he/she provides services to. The community health worker is trained in basic health care by health professionals.

The IHE is a health standard that enables the interoperability of HIS within the health domain (Integrating the Healthcare Enterprise, 2014). It allows access to and sharing of health information electronically, thereby improving the speed, quality and security of patient data. In the Namibian context, however, there is a need to have systems in place that can support community health workers as they exchange information from their remote locations. Therefore, there is a need to have a standard way in which health information from community workers can be exchanged with the DHIS-2 and silo systems. This study proposes this through the adaptation of the Cross-Community Patient Discovery (XCPD).

6.7.2 Architecture for CHW sourced information

As shown in Figure. 67, the community health worker can use a mobile device to report back disease surveillance occurring in the 14 regions in Namibia in real-time and the crowd source user or community health workers can request disease surveillance information from the DHIS.

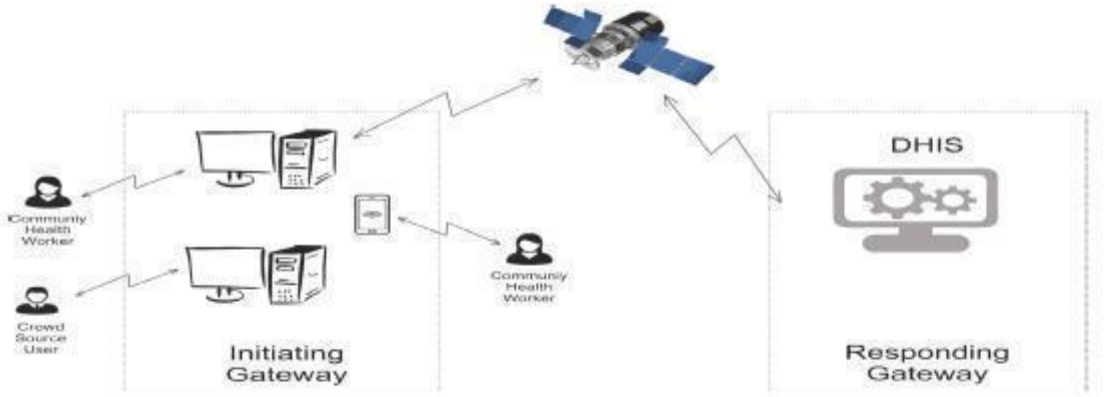


Figure 64: Architecture for the CHW mobile devices

6.7.2.1 The IHE-profile: cross-community patient discovery (XCPD)

The IHE, through its Information Technology Infrastructure Technical Framework Volume 2b Transaction B provides a Cross-Gateway. The Cross-Community Patient Discovery (XCPD) profile supports the means to locate communities which hold patient-relevant health data as well as the translation of patient identifiers across communities that hold similar patient data (Angula & Dlodlo,2018). The XCPD profile can be adapted to support communication between the CHW, the DHIS-2 in the MoHSS and the silo HIS in the regional hospitals, for them to share and also to exchange information within a health information exchange ecosystem. At the present moment, the DHIS-2 and the silo health information systems work in isolation simply because these HIS are heterogeneous, they are not interfaced and also not distributed. The study sought to develop a framework to enable the semantic interoperability of the DHIS-2, silo systems and CHWs for data semantic interoperability so that they can exchange disease-surveillance information.

The Cross-Community Patient Discovery (XCPD) was identified in this research as the closest profile that suits current challenges experienced by community health workers in the Namibian health environment. It is used in this as a support to locate communities that hold patient relevant health data and also in the translation of patient identifiers across communities holding the same patient's data (ITI) Technical Framework (2014) (Fig. 69)

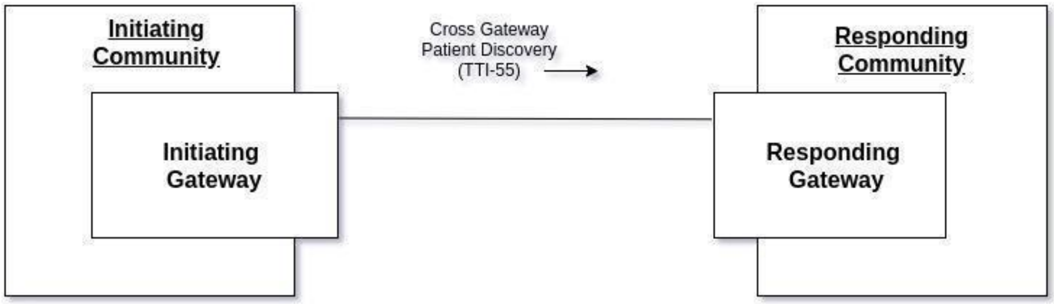


Figure 65: The community health workers profile adapted from cross-community patient discovery

6.7.2.2 Initiating gateway

The gateway is a server that acts as an entry for a local network when it is in communication with other networks. The purpose of the Initiating Gateway is to carry outgoing messages. These messages have to be synchronous in real-time. The communication supported by the gateway consists of software/hardware which is in the form of a router that connects a network to another. The software is uploaded onto the gateway. The security features of the network are also uploaded onto the gateway. From a data perspective, controls are put on the gateway on what incoming or outgoing data is allowable on the network, or what data is acceptable. When it comes to health data, privacy is of vital importance. Only certain systems or networks can access health data that is exchanged between the CHW and the DHIS-2 and any other silo HIS. The Cross-gateway patient discovery profile was identified from HL7 standards as the closest to suit the integration of disease surveillance information obtained from community health workers with the DHIS-2.

6.7.2.3 Responding gateway

The responding gateway is meant to support all incoming inter-community health workers' traffic. Therefore, XCPD utilizes this actor to receive the Cross-Gateway Patient Discovery [ITI-55]. The responding gateway supports Asynchronous Web Services Exchange on all transactions that are implemented. This allows the Initiating Gateway to choose the better of the two messaging formats (synchronous or asynchronous) that fits the needs of the workflow. The support for Asynchronous Web Services 6400 Exchange allows for workflows which scale to large numbers of communities because it can handle latency and scale more efficiently.

6.7.3 Community health worker identification segment

The focus is to have healthy communities through providing the means for the early detection of diseases. Therefore, health services have to be taken to the people through CHW since there is a shortage of health personnel in remote areas. For the HL7 standard to support this, it needs to have the following codes, as shown in Table **71**:

Table 71: HL7 code

Code	Meaning
XCN-1	Person ID
XCN-2	Family Name
XCN-3	Given Name
XTN-1	Telephone number
AD-1	Street address
AD-2	Other designation
AD-3	City
AD-4	State
AD-5	Postal code

An extract from the message header is structured as follows in Table 71

Table 72: Message header extract: Adapted from Health Level Seven technical report

Sequence	Length		Code	Element name
1	1		ST	Field separator
2	4		ST	Encoding characters
3	18		HD	Sending application
4	18		HD	Sending facility
5	18		HD	Receiving application
6	18		HD	Receiving facility
7	26		TS	Date/Time of message

6.8 Hospital-to-hospital case study

The following is a case study of the hospital-to-hospital case study that utilises the interlink protocol and the Patient Demographics Actor profile

6.8.1 The architecture for distributed health institutions

When data is captured in different public health institutions, it is in different formats, meaning that each time a patient visits a different health institution, they have to open a new file. To enable interoperability of data, the application of a JSON-based interlink protocol to disease surveillance data from silo health systems in Namibia is characterized by the following, as shown in Figure 70 1

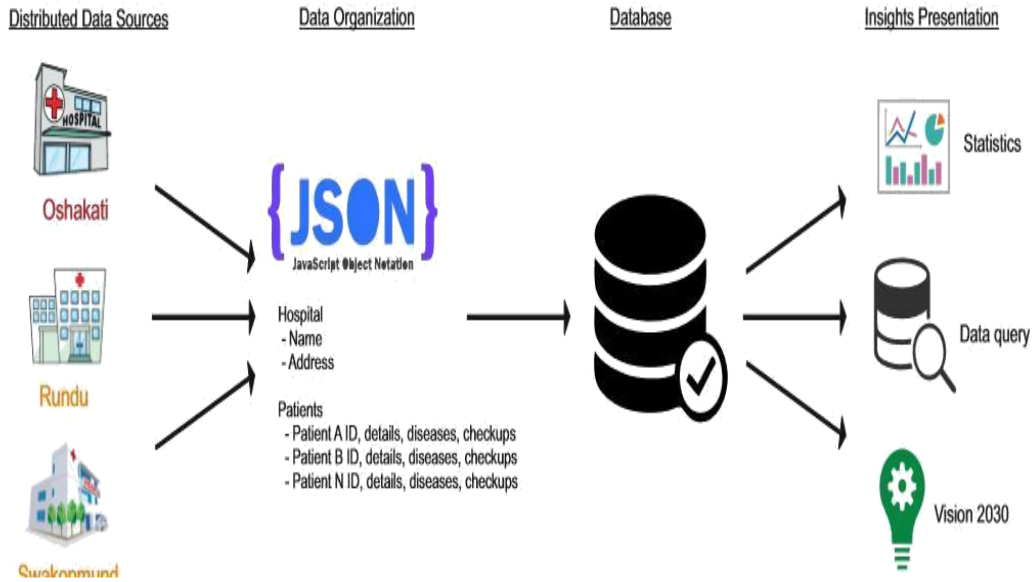


Figure 66: Architecture for the semantic interoperability of data from distributed health institutions

6.8.2 Example of architecture of the integrated hospital system

Figure 71 shows an example of four HIS of DHIS-2, ETR.net, EDT and EPI Info which are hosted of different public hospitals in Namibia. When a patient visits a hospital, they are allocated a hospital identifier for the day. This identifier is unique to the hospital on the particular day. For example, it may indicate the patient number in the queue in that hospital for that particular day. The local identifier, plus the demographic details of the patient are transferred to the common registry for all hospitals for documenting the history of the treatment of the patient. If the patient visits a different hospital, the same procedure takes place. The additional event is that the demographic data from the second hospital is compared against the demographic data already in the registry to extract the medical history of the patient.

An example of how the processes work can be explained using the following example. If a patient visits Windhoek Central Hospital, for example, the DHIS-2 sends a query to the Health Information Exchange (HIE). HIE is middleware that facilitates exchange of information. The Health Information Exchange (HIE) has a registry (the equivalent of EMPI) and a repository. In the registry, the patient visit to Windhoek Central is allocated a unique local Windhoek Central hospital related number to the patient. The unique Windhoek Central hospital-related unique number and the demographic details of the patient go into the registry. When the ETR.net that is housed in Katutura hospital sends a query to the registry about a patient whose details have just been captured as a result of their visit to Katutura hospital, demographic details from this hospital are compared with what is already held in the registry in order to extract the history of the patient from the registry. This means that mobile patients can visit any hospital and there will be continuity in their treatment by virtue of the fact that their history can easily be extracted from the system. The repository on the other hand keeps documents such as MRI scan, CDA documents on each and every patient, which can be referenced.

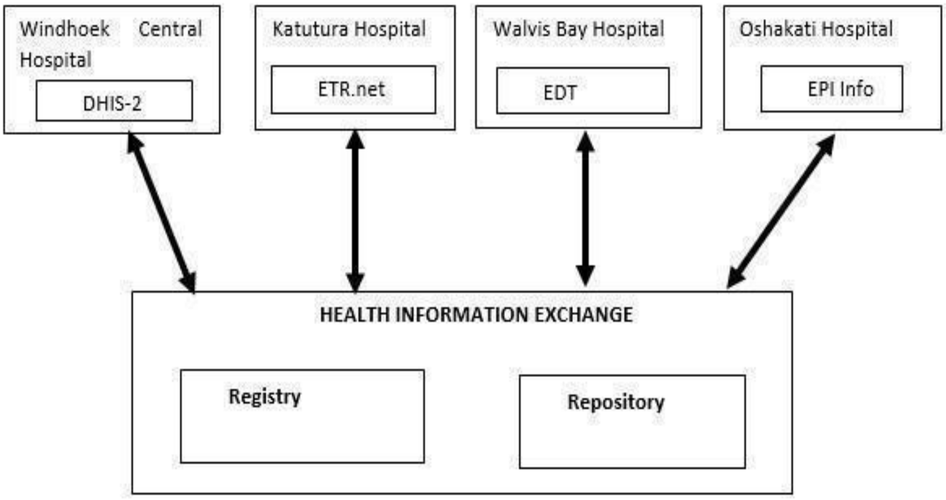
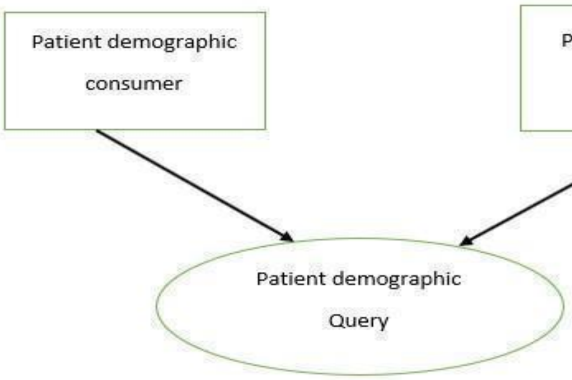


Figure 67: Architecture of integrated system

6.8.3 Profile for hospital-to-hospital

The IHE IT Infrastructure Technical Framework has different profiles. The profile selected for Namibian disease surveillance data case to comply with IHE standard corresponds to Transaction ITI-21 of the IHE Technical Framework. Transaction ITI-21 is used by the Patient Demographics Consumer and Patient Demographics Supplier Actors. In this transaction, the Patient Demographics Consumer Actor is requested for information about patients that have demographic data which is matching the data provided in the query message. The request is received by the Patient Demographics Supplier Actor. The Patient Demographics Supplier Actor successively processes what has been requested and the response is returned in the form of demographic information that is used to match the patients. The general use case role of the profile is as follows (see Figure 71):

Figure 68: Patient demographic actor



(Adapted from IHE Technical Frameworks)

Therefore, the processes are as follows:

- Actor: The Patient Demographics Consumer Role makes a request for a list of patients that match the specified set of demographic criteria such as the ID or name from the Patient Demographics Supplier. The Patient Demographics Consumer populates the attributes with the demographic information that is received from the Patient Demographics Supplier. The consumer in this case is the HIS that is housed in the hospital, such as DHIS-2, ETR.net, EDT or EPI Info. The supplier in this case is the Registry section of the hospital.

- Actor: The Patient Demographics Supplier Role returns demographic information for all the patients that match the demographic criteria that is provided by the Patient Demographics Consumer to the consumer.

6.8.4 HL7 code explanation

The Health Information Exchange Structure's registry should match the HL7, i.e. the HL7 fields to match the registry. The queries from DHIS-2, ETR.net, EDT and EP Info should be standardized to suit the registry. For example, all the HL7 codes of AD-1, AD-2, etc. should be available in the queries. Looking at the following example:

Let us suppose that the DHIS-2 system captures the following data:

Table 73: DHIS-2 systems capture

Name (NNWindhoek Central)	Surname (SS-Windhoek Central)	Address (AA-Windhoek Central)	National ID (ID-Windhoek Central)
John	Smith	5 Kleine Kuppe	6578823

Let us also suppose the ETR.net system in Katutura Hospital captures the following data:

Table 74: ETR.net systems capture

Name (NN-Katutura)	Surname (SSKatutura)	Address (AA-Katutura)	Next-of-kin (NK-Katutura)	Passport number (PN-Katutura)
Andrew	Gonzalez	123/56 Katutura	Bedford	DF4279QD

The registry should have all the fields that are available in the HL7 code, in the standard code syntax.

Table 75: Registry data

Person ID (XCN-1)	Family Name (XCN-2)	Given Name ((XCN-3)	Address (AD-1)	Telephone (XTN-1)	Designation (AD-2)	State (AD-4)
6578823	Smith	John	5 Kleine Kuppe	-	-	-
DF4279QD	Gonzalez	Andrew	123/56 Katutura	-	-	-

This is all about matching the HIS in the different hospitals with the registry at the MoHSS. The queries for DHIS-2, ETR.net and EPI Info [are standardized to suit the registry. Match the names NN-Windhoek Central and NNKatutura with the name in the registry XCN-3. Match the surnames SS-Windhoek central and SS-Katutura with the family name XCN-2 in the registry. In this example, the nextof-kin (NK-Katutura) does not have a representative code in the registry. Therefore, when updating the systems, it is only the local ETR.net in Katutura hospital that is updated, and the information is discarded without error when it comes to updating the registry. If not given any value, default values will be put in the registry.

The information should be traceable, that is, obtained from the header which has the sending facility, sending software, etc. The sequence in the message header is standard. Whenever a message goes out, it follows the established format of the header in terms of the sequence of the fields and the length of each field. The user need not know the format of the header. There should also be privileges on who can update the registry. There is also the issue of how much information is availed to the person querying. There should be different access rights for the different medical personnel. For example, when HL7 provides clinical information, suppress certain information if it's a nurse accessing the information as opposed to a doctor accessing.

An extract from the HL7 code, for example can be structured as follows in Table 76:

Table 76: HL7 code extract: adapted from health level seven technical report

Code	Meaning
XCN-1	Person ID
XCN-2	Family Name
XCN-3	Given Name
XTN-1	Telephone number
AD-1	Street address
AD-2	Other designation

AD-3	City
AD-4	State
AD-5	Postal code

An extract from the message header is structured as follows in Table 77:

Table 77: Message header extract: adapted from health level seven technical report

Sequence	Length	Code	Element name
1	1	ST	Field separator
2	4	ST	Encoding characters
3	18	HD	Sending application
4	18	HD	Sending facility
5	18	HD	Receiving application
6	18	HD	Receiving facility
7	26	TS	Date/Time of message

The HL7 message outlines the intent, source, destination, and some specifics of the syntax of a message as contained in the message header and the message code. The HL7 message has, as a minimum, details of the sending application, sending facility, receiving application and receiving facility.

6.8.5 Enterprise master patient index

The Enterprise Master Patient Index (EMPI) Master Patient Index (https://www.openempi.org/) is a patient database that is used by health care organisations in the maintenance of accurate medical data throughout the many departments. The EMPI maintains a unique identifier for every patient in the enterprise. These enterprises may be medical centres, outpatient clinics, doctors' practices, rehabilitation facilities, etc. The entire registration systems in the enterprise consult the EMPI to get patient information and this is reliant upon several identifiers. Whether in electronic or paper format, an accurate EMPI is the most critical resource within a healthcare facility as it provides the link that can track the patient activity within an organisation (or enterprise) and also across various patient-care settings. Patient care may be compromised if the patient cannot be identified or access to patient information is curtailed.

The recommended data elements of an EMPI are: The Enterprise Identification Number which provides a unique patient identifier across the health enterprise; Facility identifier, which is utilised to locate the facility that contributes data to the EMPI; Internal Patient Identification, which is used by the facility to identify a patient during admission; person's name, date of birth, gender, ethnicity, residence, alias/maiden name, ID number and telephone number. This means that the EMPI extracts the medical records or ID associated with a patient's name and that data should have adequate demographic data to quickly identify a patient and his/her records. If more than one healthcare facility is served by the EMPI, the index must also specify the facility where the admission took place, or where the encounter occurred. The role of EMPI has increased due to the integration of healthcare delivery systems across multiple hospitals and the vertical integration of hospitals, physician practices, homecare agencies, etc.

6.9 The technology demonstrator

The disease surveillance demonstrator that utilizes this protocol is as shown below in Figure 73 6. The user can login through user login interface using their credentials, that is, the username and password.

Figure 69: **Login interface**

This is a login interface for DHIS-2 which enable users to login into system with their username and password. If the user credentials are incorrect the user will not login to the system.

The user can then view a dashboard with information uploaded from different data sources in all the 14 regions in Namibia, as shown in Figure 74.

Hospitals / Clinics

Erongo Mobile Clinic
Okahandja State Hospital
Okahandja, Otjozondjupa
Edit hospital/clinic
Records 2

Onandjokwe Test Center
Test Center
Ondangwa, Oshikoto
Edit hospital/clinic
Records 1

Erongo Mobile Clinic
Mobile Clinic
Swakopmund, Erongo
Edit hospital/clinic
Records 2

Grootfontein Hospital
State Hospital
Windhoek, Otjozondjupa
Edit hospital/clinic
Records 2

Figure 70: Distribution of diseases

The map symbolises the geographical location a particular disease occurred in any of the 14 regions in Namibia, as shown in Figure 75.

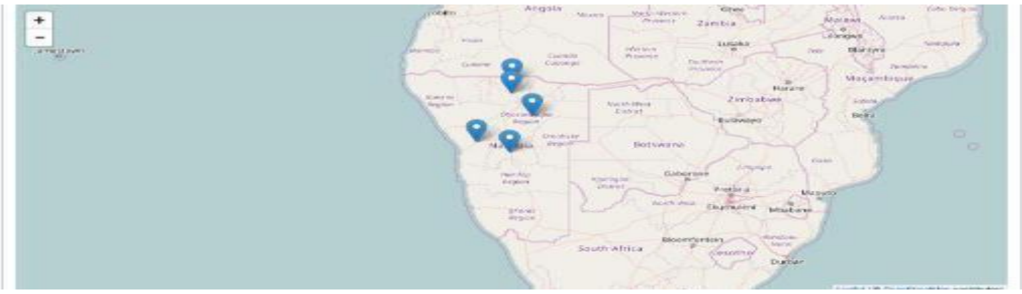
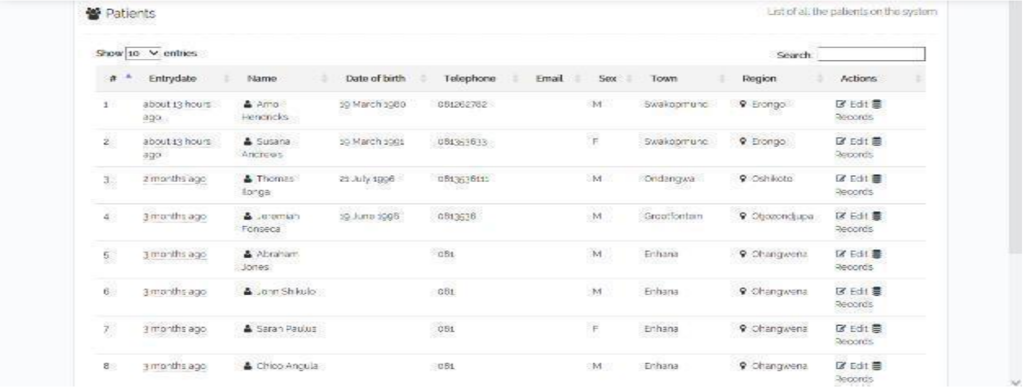


Figure 71: Geographic location

The next screen enables a user to filter the type of disease a particular patient is suffering from. This is shown in Fig. 76.

Figure 72: Filtering by type of disease

Figure 77 is a list of all patients in the integrated system and Figure 77 is a list of diseases. With the system manage tab the user can view patients, diseases, hospitals and patient records on the system. With the upload data tab, the user can upload data under this tab provided the data is structured into JSON format. With the system setting tab the user can create user account on the systems and administrator can manage the system under is tab.


Patients

List of all the patients on the system

Show 10 entries

Search:

#	Entrydate	Name	Date of birth	Telephone	Email	Sex	Town	Region	Actions
1	about 13 hours ago	Arno Hendricks	19 March 1980	081262782		M	Swakopmund	Erongo	Edit Records
2	about 13 hours ago	Susana Andrews	19 March 1991	081363633		F	Swakopmund	Erongo	Edit Records
3	2 months ago	Thomas Iionga	21 July 1996	0813636111		M	Ondangwa	Oshikoto	Edit Records
4	3 months ago	Jeremiah Fonseca	19 June 1998	0813636		M	Grootfontein	Otjozondjupa	Edit Records
5	3 months ago	Abraham Jones		081		M	Enhana	Ohangwena	Edit Records
6	3 months ago	John Shikulo		081		M	Enhana	Ohangwena	Edit Records
7	3 months ago	Sarah Paulus		081		F	Enhana	Ohangwena	Edit Records
8	3 months ago	Chico Angula		081		M	Enhana	Ohangwena	Edit Records

Figure 73: List of patients on the system

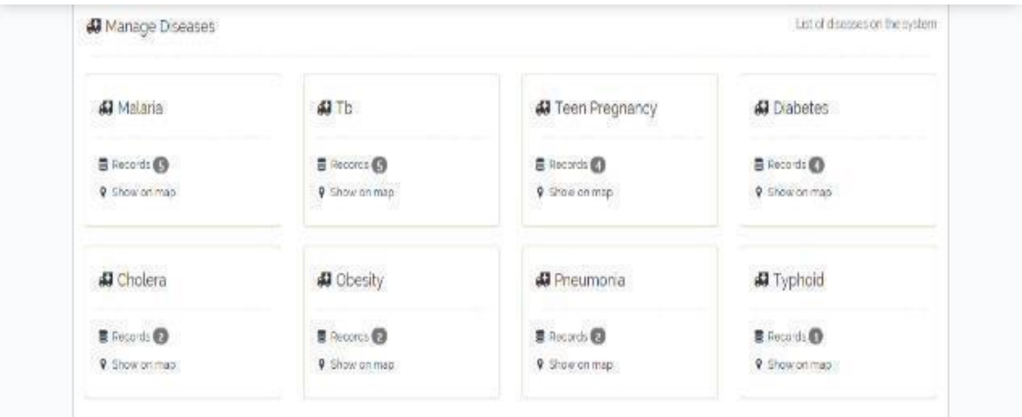


Figure 74: List of diseases in the system

6.10 Benefits of the system

There are a number of benefits that the semantic interoperability of HIS achieves. One of these is that the patient can access health services at any health institution and their medical history can easily be retrieved even if the record was not captured in the same institution they are visiting. The doctors have a complete view of the patient's medical history irrespective of where they are. The system is able to aggregate disease surveillance data from multiple heterogeneous HIS in the Namibia health domain at the same time. The system data exchange scheme and standards are able to permit disease surveillance data to be shared across clinicians, laboratory, hospital, pharmacy and patients regardless of the application or application vendor within the Namibian health domain. The system has a capability to allow the disease surveillance data exchange between health organisations in Namibia across organisational boundaries in order to advance the effective delivery of healthcare to individuals and communities. The Interlink protocol enables the aggregation of disease surveillance data from the different HIS which have different data structures and are developed using different software on varied platforms. When data is automatically transferred from one system to the next, this reduces the occurrence of errors. The integration of disease surveillance data facilitates easy, informed and real-time decision-making. Therefore, the integration of data breaks down the silos in medical health. At the end of the day the customer, who is the communities has increased satisfaction.

6.11 Conclusion

In the Namibian health domain there is no known protocol to govern or aggregate disease surveillance data from remote heterogeneous health information systems. Therefore, the study developed an interlink protocol that can aggregate disease surveillance data from remote systems. The protocol is based on JSON format. To test the protocol, a prototype was that uses the protocol was designed. The prototype enables the integration of disease surveillance data and the production of reports for decision-making. The health professionals in Namibia would use the system for fast decision making simply because they are accessing disease surveillance data in real time. The next chapter covers research summary and conclusion.

CHAPTER 7: RESEARCH SUMMARY AND CONCLUSION

7.1 Introduction

The Centre for Disease Control (CDC), MoHSS in Namibia is experiencing challenges in accessing disease surveillance information timely in its head office in Windhoek. CDC regional offices are also finding it difficult to access communicable and non-communicable disease information on time from the CDC regional sub-offices. Currently, it takes on average, about a month for CDC regional offices to access disease surveillance information from the regions after an incidence has been reported. The current method of communicating disease surveillance information is not appropriate, as it does not support real-time access to information from regional offices across the country for prompt decision-making. Currently data is expected to be communicated to the CDC through the Directorate of special programmes in the MoHSS that deals with HIV/AIDS, TB and malaria and the primary healthcare directorates in the Ministry of Health and Social Services (MoHSS). The data are only communicated from official sources and not directly from the affected communities. Old fashioned data communication methods such as the email and/ or phone calls are used as the official communication channels although the Namibian health sector has a range of heterogeneous health information systems (HIS) in place in addition to access to telecommunication networks. Such methods of communication are not appropriate in cases of emergency, that is, when there is an outbreak of disease that has to be contained promptly to demonstrate how disease surveillance data can be integrated. This chapter gives an evaluation of how far the research objectives were met.

7.2 Summary of findings of the research study

The findings of the study were driven by research objectives. In this section each of the findings were discussed based on the research objectives.

Research objective 1: **To assess how disease surveillance data are currently exchanged/ shared between the existing DHIS-2 and silo systems in Namibia.**

The study interviewed CDC staff members, public hospitals and MoHSS through semi-structured interviews to determine how disease surveillances data is currently shared between CDC, MoHSS and public hospitals. A total of 800 questionnaires were distributed to the public hospitals of 8 regions in Namibia, to get the views of individuals on how disease surveillance data is exchanged or communicated among CDC, MoHSS and public hospital members. The researcher had an opportunity to interview 1 Chief computer technician, 4 Technicians, 2 system administrators, 1 Senior system administrator, 2 Chief system administrators, 1 Chief analyst programmer, 2 Analyst programmers, 1 Senior Analyst programmer, 1 Data analyst(HIS), 1 HIS technical advisor, 1 National surveillance officer, 1 Senior health programmer, 6 Registered nurses, 1 Doctor,1 Student doctor, 3 Student nurses,2 NIP Technicians (laboratory and 3 Enrolled nurses at two hospitals in the Khomas region, namely Katutura State Hospital, CDC, Windhoek Central Hospital and the MoHSS. A total of 18 health professionals from Katutura State Hospital and Windhoek Central Hospital and 16 IT professionals from the MoHSS participated in the study. The cumulative percent and frequency in each age group means the participants indicated that the current methods used to exchange and communicate disease surveillance data is a manual paper based systems which are not efficient and effective. The participants indicated that each hospital have driver who transport disease surveillance information from one hospital to the other and from the regional level to national level in a form of manual paper based systems. The participants indicated that the type of disease surveillance data exchanged and communicated from the regional level and national level are sentinel surveillance, accelerated disease control - national active and

national passive. The participants indicated that the Ministry of health and social services as custodian to facilitate the process of exchanging and communicating disease surveillance data should adopt a health integrated surveillance systems that can aggregate data from different hospitals in the 14 regions of the country.

The overall findings concluded that the current methods used in the Namibian public hospitals is a manual paper based systems that is inconsistency in disease surveillance data entry, room for errors, miskeying information, time consuming and costly to produce reports. The findings in Erongo indicated that Erongo region had 30 participants who responded on how public hospitals in Namibia can exchange and communicate health related information with other hospitals; how they access healthcare information from other public hospitals in Namibia; what type of healthcare information from other public hospitals in Namibia; as well as how they would prefer to receive healthcare information from other public hospitals. with 100% agreed that there is delay in accessing disease surveillance data from other public hospitals. The finding in Kara indicated that Karas region, a total of 20 participants were engaged in the study of which 9 males and 11 females participated in the study and indicated that the method used to exchange and communicate data is manual system which is not appropriate and time consuming in communicating and exchanging of disease surveillance data between hospitals in the Namibia health institutions. The percentage of males was 45% while for female is was 55%. The males were 9 and the females were 11, in total both male and female were 20. The findings in Khomas region indicated that in Khomas region a total of 35 participants, participated in the study of which male were 16, females were 19. The participants include both male and female which means the number of males was 16 with a percentage of 45.7% and the number of females was 19 with the percentage of 54.3%. A total of 33 participants (males and females) in Kunene region participated, of which 32 indicated that they exchanged disease surveillance data or health related information from other hospitals through a traditional manual system.

The males were 20 (60.6%), while females were 13 (39.4%) based on their gender. In Ohangwena region a total of 30 participants (including males and females) stated that public hospitals and health institutions in Namibia currently access, exchange, communicate and share disease surveillance data manually with other public health institutions and the most common method used to share health related information is through circular, etc.

The participants were females and males. The males were 16, females were 14 of which 53.3% represented males and 46.7% represented females. In Omusati region a total of 27 participants, which includes both males and females, participated and stated that the current methods of exchanging, communicating disease surveillance data is a manual system which is not appropriate when health professionals are making health strategic decisions. The participants were males and females. The number of male was 12 and the number of females was 15.

In Otjozondjupa Region, a total of 21 participants indicated that as public hospital in Namibian they access, exchange, communicate disease surveillance data from one hospital to the other through a traditional manual system. The participants were male and female based on their gender. The number of males was 10, females were 11. The percentage of males was 47.6% and the percentage of females was 52.4%. In Zambezi Region total of 27 participants (both males and females) in Zambezi region participated in the interview questionnaires of which majority of the participants indicated that the current methods used in public hospitals or health public institutions in Namibia is a manual process which includes circular, email, telephone calls, circular, flyers and pamphlets which is not appropriate in case of emergency when an incident is reported. The participants also indicated their preferences on how they wanted to access, receive, exchange and communicate disease surveillance data among public hospitals and other health public institutions in Namibia. The participants age group were between 18-25 years, the age group between 26-35 years, the age group between 36-45 years, and the age group above

45 years. The percentages of age groups: between 18-25 was 22.2%, between 26-35 years was 48.1%, between 36-45 years was 18.5% and above 45 years was 11.15%. The participants indicated that currently in every district public hospital and central hospital there is a department/center of disease control (what we call CDC) this specific center is the one responsible for collection and diseases surveillance information. For instance, an incidence of a communicable disease is established in a specific hospital at an infectious department, it is a responsibility of a supervisor/head of that department to make sure this new case is reported at CDC and hospital management is informed too. It is after then that CDC of such hospital information/ convey this case to a regional level (to the regional health director) who then has to see that this detail has reached the headquarter (minister of health).

The results indicated that the CDC, MoHSS and the public hospitals in Namibia do not have a comprehensive standards-based framework for enabling semantic interoperability of disease surveillance data for Namibia through adopting health standards. Currently in Namibia there is a lack of a mechanism for semantic interoperability to aggregate disease surveillance from multiple heterogeneous HIS. There are no known protocols for semantic interoperability that have been adopted by the MoHSS and customized to the Namibian health environment. Currently the CDC, MoHSS, and public health institutions in Namibia encounter a challenge of a lack of disease surveillance data aggregation from heterogeneous HIS which negatively impacts health service delivery when health decision making is to be implemented within the Namibian health domain [14]. The lack of disease surveillance data aggregation among health institutions in Namibia creates a gap when health professionals want to access real-time disease surveillance information. As it stands, health administrators working in the 14 regional sub offices communicate disease surveillance information to the head office in Windhoek through USB or manually through sending technicians with physical files to the regions for import into the system [

Research objective 2: **To examine how existing DHIS-2 and silo systems in Namibia can be interfaced.**

The study interviewed CDC staff members and MoHSS using semi-structured interviews to determine disease surveillance data through adopting health standards. Majoring of the participants indicated the current method to communicate and exchange disease surveillance through circulars, meetings and workshops.

The participants indicated that information sharing in disease surveillance system is being done through daily basis reports (if possible/suspected case is established from clinic level / from health care centers that are in remote areas, they then do referrals of patients (with a suspected case) to the district hospital for case/outbreak investigation. District hospital then reports to region upon confirmatory of a new case. Some participants indicated that, it depends on the type of information send on a daily basis or other send on a weekly/monthly basis. Some of the data takes a long time for the lack of training on the importance of frequent reporting /or on the system of reporting. Some participants indicated that, they receive disease surveillance data through pamphlets and memorandum. Furthermore, participants indicated that disease surveillances information is received through PS and medical superintended office. The participants indicated that the people that work in health information system office communicate with each other and each person will that take information to their respective departments and if there is a need for assistance then they will choose who should go**.** Moreover, these are the only methods currently availability to communicate and exchange disease surveillance data. The participants indicated that they receive disease surveillance data or information through regional circulars/memos, telephonically, verbally (during workshops, in-service training or supervisory support visit and through DHIS-2 which is only accessible to view only information for a specific hospital and users are not able to view information for another public hospital in another region.

Some participants stated they received disease surveillance data through feedback
by workshops and introduction of system applications.

Research objective 3: **To develop a data interlink protocol/profiles that would govern heterogeneous health information systems in Namibian public hospitals through adopting health standards.**

The study used semi-structured interviews on CDC staff members, MoHSS to determine the current technologies used by CDC to exchange and communicate disease surveillance data through adopting health standards. The study adopted three integrated health standards profiles and an interlink protocol for aggregating disease surveillance data which allow the remote systems to organise their data in a certain format (that is a protocol). That format is a JSON object. That JSON file created by the remote system is then uploaded into a database. A PHP (Hypertext Preprocessor) file will get all the data from JSON file and insert into tables. Hence, it is JSON structure that holds the data and that data is inserted into database tables. The protocol function in converting different data structures to enable aggregation of data is technically defined in the source codes and this is the protocol agreed upon between DHIS system and remote systems called interlink protocol.

Research objective 4: **To design and develop a comprehensive standards-based framework to enable semantic interoperability of data in heterogeneous health information systems in Namibian hospitals through adopting health standards.**

The study collected data from the public hospitals through questionnaires to determine the issue of disease surveillance data communication and exchange in heterogeneous health information systems in Namibian health environment. The participants indicated that there is a need to come up with a real-time electronic communication network whereby hospitals can access reports without delays. However, there are safety concerns regarding the electronics in facilities since most facilities in the country have been broken into several times and a numerous valuable items such as office computers and TVs for patients have been stolen and never recovered. Furthermore, the lack of access to stable internet connection countrywide is a limitation to this approach. There should be a formal platform for the facilities to facilitate communications in sharing with each other on disease outbreaks or prevalence. The government could embark on a modern affordable portable computer such as tablets which have some useful programmes that can facilitate inter-facility communications. But they will also need to improve the infrastructures for example secure storage of the electronics at the end of the day and network and also system should have features to integrate. For proof of concept, this research developed a prototype to demonstrate how disease surveillance data can be integrated.

7.3 Revisiting research questions

The main research question was: “How can the comprehensive standard-based framework for disease surveillance data semantic interoperability of DHIS-2 and these other health information silo systems for them to exchange disease surveillance data and information be achieved using health standards?”

Research question 1: **How is disease surveillance data currently shared between existing DHIS and silo systems in Namibia through adopting health standards?**

The research question was answered through the responses of the participants involved. They indicated that the current methods to exchange and communicate disease surveillances data is through memos and circulars. However, as a result of poor and inefficient communication of disease surveillance information, there is little or no data coming in from the regions for real-time decision-making in cases where outbreak of disease requires prompt action. The methods used currently to communicate data from the regions to the CDC are emails or phone calls. These methods are not appropriate in cases of emergency in disease control

The research question was therefore answered. The study interviewed CDC staff members, MoHSS through semi-structured interviews to determine how disease surveillances is currently shared between CDC, MoHSS and public hospitals. The results indicated that the CDC/MoHSS and public hospitals do not have a technology platform to aggregate disease surveillances data through the adoption of health standards.

Research question 2: **How can information relating to disease surveillance data be interfaced between existing DHIS and silo systems in Namibia by adopting health standards?**

The research question was answered according to responses of the participants who indicated that health community officers go in the field to train community members in all the 14 regions in Namibia and these regions are far apart from each other. Therefore, the study developed three integrating profiles for patient demographic, community health workers and crowd source user profile through adopting health standards and an interlink protocol.

The fact that the HIS in Namibia exist as silo systems as a result of uncoordinated procurement practices means that they do not share and exchange information with each other. These systems exist as silos at semantic, syntactic and social levels. Although standards for the integration of health information systems are in place internationally, Namibia can only take advantage of these going into the future, because the current status quo of heterogeneous distributed systems cannot be reversed. However, that does not stop the Namibian researchers from proposing a way forward on integration of the HIS. This research proposes the adoption of IHE, HL7 and the Enterprise Master Index standards for the interoperability of systems to interface the silo HIS for data level semantic interoperability. Huge amounts of information are generated in disease surveillance. Since this information is captured using different HIS, e.g. DHIS-2, ETR.net, EDT or EPI Info, their structure is highly likely different as a result of being from different vendors. This information is needed by the MoHSS for decision-making on disease surveillance. This information is heterogeneous in terms of schema, syntax, semantics, data types, and data format and data constraints resulting in severe data interoperability problems. Therefore, there is a need for the standardization of HL7 for common message structuring for message exchange between HIS and the adoption of IHE. The benefits of standards are felt in the areas of patient management, hospital management, ambulatory services, clinical management, government and vendors. The systems are enabled to speak the same language, as well as to recognize the structure, formats and core codes that are used in their communication. This is what is currently lacking in the Namibian health domain.

Research question 3: **How can a data interlink/ profiles protocol that can govern heterogeneous health information systems in Namibian public hospitals are developed whilst adopting health standards?**

The research question was answered considering the responses of the participants that indicated that health community officers go in the field to train community members in all the 14 regions in Namibia and these regions are far apart from each other. Therefore, the study developed three integrating profiles for patient demographic, community health workers and crowd source user profile through adopting health standards and an interlink protocol that can aggregate disease surveillance data from heterogeneous health information systems in Namibia.

In the Namibian health domain there is no known protocol to govern or aggregate disease surveillance data from remote heterogeneous health information systems. Therefore, the study developed an interlink protocol that can aggregate disease surveillance data from remote systems. The protocol is based on JSON format. To test the protocol, a prototype was that uses the protocol was designed. The prototype enables the integration of disease surveillance data and the production of reports for decision-making. The health professionals in Namibia would use the system for fast decision making simply because they are accessing disease surveillance data in real time. The system will aid in health decision-making because the system has the capability of aggregating data from remote systems. It will organize data coming from different HIS or from different health facilities in Namibian public institutions. This would address the current problem of a traditional method of accessing, exchanging and communicating disease surveillance data from one public health institution to other public health institutions. The system has the ability to organize distributed data source from heterogeneous health system without changing the content of the data as long as data can support JSON format and as result the representations of data will be displayed in the format of pie charts and graphs. The charts and bar graphs show the health institutions source, geographical location, gender, type of disease. In addition, the system will offer public health institutions in Namibia the opportunity to access disease surveillance data in real-time for decision-making. The health professionals will be enabled to work jointly when making health decisions. The system will allow disease self-management which means health professionals will access all the disease information from different sources. The different HIS are hosted by different organisations, hence interoperability would be a challenge to make the system work in all health institutions in Namibia. It can only be possible in public health institutions as the stakeholder is the government. The availability of skills to undertake this project would be a determinant in the success of the project. There should be buy-in at a national level for a policy on integration to come to fruition. The prototype that is currently in place is only for proof of concept and will require further development for the purpose of commercialization.

Research question 4: **How can a comprehensive standard-based framework to enable semantic interoperability of disease surveillance data in heterogeneous health information systems in Namibian hospitals be designed and developed through adopting health standards?**

This question was answered. The three integrating profiles/ can allow aggregation of disease surveillances data timeously, an interlink protocol that can aggregate disease surveillance data from heterogeneous health information systems in Namibia. The proposed framework works as follows:

When data is captured in different public health institutions, it is in different formats, meaning that each time a patient visits a different health institution, they have to open a new file. To enable interoperability of data, the application of an interlink protocol to disease surveillance data from silo health systems in Namibia. There are JSON files from different public health institutions. As long as these files are in JSON format, the system will accept and produce statistics form them. Based on the information uploaded on the system, health professionals can view analysed data on the dashboard and can easily make quick decisions based on the information. The standard interface to enable aggregation of data is The rule of aggregating data is coded as a layer to allow remote systems and DHIS-2 system to exchange disease surveillance data with each other in a meaningful manner. The aggregated data is used in the production of, for example, reports to be used in decision-making. The study therefore has identified a new protocol called interlink protocol in the Namibian public health sector that would act as converter to interpret data from different data sources.

7.4 Recommendations pertaining to future research

The study is recommending future researchers to consider all aspects that were not covered in this research. In addition, anything that was not included in this research should be considered in future studies. The interlink protocol should be further refined. The study used HL7 as a set of international standards for the transfer of clinical and administrative data between software applications used by various healthcare providers hence, further studies should consider ICD-10 as the foundation for the identification of health trends and statistics globally, and the international standard for reporting diseases and health conditions.

7.5 Conclusion

CDC, MoHSS and public hospitals in Namibia are experiencing challenges in accessing disease surveillance information timely, not only CDC but also the regional offices from the sub-regional offices. The length of time ranges from a month to more. The methods used in communicating disease surveillance information do not support prompt decision making. Currently disease surveillance data came from official sources and not from unofficial sources. The methods of communication are emails and telephone calls which are not real-time. It is for that reason that this research proposed crowdsourcing information through mobile phones that are in the hands of the communities. The information from the mobile phone should integrate with the heterogeneous information systems, it is for that reason HL7 interoperability standards come into play. The retrieval display profile was identified from the HL7 standards as the closest to suit the integration of disease surveillance information with the HIS. The framework for crowdsourcing interoperability would make it easier to collect disease surveillance information. The CDC support the MoHSS to conduct disease surveillance activities, monitor and evaluate such activities. The study proposed crowdsourcing to capture disease surveillance data since the usage of mobile phone in Namibia is 100%. The problem in Namibia's health sector is that there is a plethora of silo HIS that generate much data which cannot be integrated for efficient decision-making due to the fact that these silo systems do not communicate with each other. Almost all public hospitals in Namibia host an HIS of one form or the other, but sharing the data they produce with other hospitals and with the MoHSS is curtailed resulting from the lack of interoperability. Namibia is yet to adopt these standards, hence the motivation for this research.

The study developed a framework for interoperability of HIS for disease surveillance data from CHW through adopting the HL7 standards. For proof of concept, this research developed a prototype to demonstrate how disease surveillance data can be integrated. The Namibian health domain sends community health workers in the 14 regions to educate the community on health programmes or making the community aware of particular outbreaks of communicable and non-communicable disease. The study developed a semantic interoperability framework adopting HL7 standards.

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Appendices

Semi-structured interviews

Data collection tool (Public hospitals in Namibia)

a) What is the current methods used in the hospitals to communicate and exchange
b) non-communicable and communicable disease information to another hospitals
c) Why do hospitals opt to use that methods?
d) How do you receive disease surveillance information from another hospital?
e) Why do you receive such information in that way within the hospital setup?
f) How long does it take for health professionals to receive or send disease surveillance information to another hospital?
g) Why does it take such a long or short period of time?
h) What do you think should be done with the current systems used in the public hospitals to communicate and exchange disease surveillance information at the present moment?

Questionnaires directed to nurses, doctors, health administrators etc.

Hospital survey Questions (Questionnaires)

PLEASE TICK √ OR CROSS X TO SELECT YOUR ANSWER

Gender: Male ☐ Female ☐

Age group 18-25 ☐ 26-35 ☐

36-45 ☐ above 45 ☐

1. As a public hospital how do you exchange disease surveillance data with other hospitals?

(a) Through mobile phone ☐

(b) Through flyers ☐

(c) Through staffs ☐

(d) Through health programs ☐

(e) I don't ☐

2. How do you access disease surveillance data from another public hospitals in Namibia?

(a) Visit the hospital/clinic ☐

(b) Through Mobile phone ☐

(c) Flyers ☐

Others (please specify)

………………………………………………………………………………………………………

3. What type of disease surveillance data do you exchange with other public hospitals?

(a) Campaign related to health ☐

(b) My health record ☐
Others please specify

………………………………………………………………………………………………………

4. How would you prefer to receive disease surveillance data from other public hospitals?

(a) Visit the hospital/clinic ☐

(b)Through Mobile phone ☐

(c) Flyers ☐

Others (please specify)……………………………………………………………………………..

5. What type of disease surveillance data would you want to receive from other public hospitals?

(a) Polio information ☐

(b) Malaria information ☐

(c) Ebola Information ☐

(d)HIV/Aids information ☐

☐

☐

Others (please specify)……………………………………………………………………………

6. When accessing disease surveillance data how long does it take you to receive the information from other public hospitals?

(a) Within a day ☐

(b) Between 1-5 weeks ☐

(c) Between 5 – 10 weeks ☐

(d) Between 10 – 15 weeks ☐

Others (please specify)

…….

Questionnaires directed to ICT staffs
ICT Staff survey Questions (Questionnaires)

PLEASE TICK √ OR CROSS X TO SELECT YOUR ANSWER

Gender: Male ☐ Female ☐

Age group 18-25 ☐ 26-35 ☐

36-45 ☐ above 45 ☐

1. As ICT staff how do you exchange and communicate disease surveillance data with each other within your department and other organisations?

(a) Through mobile phone ☐

(b) Through flyers ☐

(c) Through staffs ☐

(d) Through health programs ☐

(e) I don't ☐

2. How do you access disease surveillance data from another department or organisations?

(a) Visit the hospital/clinic ☐

(b) Through Mobile ☐
phone (c) Flyers ☐

Others (please specify)

……………………………………………………………………………………………………

3. What type of disease surveillance data do you exchange with other ICT staffs who works for other organisation?

(a) Campaign related to health ☐

(b) My health record ☐
Others please specify

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4. How would you prefer to receive disease surveillance data from other organisations or other ICT Staffs?

(a) Visit the hospital/clinic ☐

(b)Through Mobile ☐

phone (c) Flyers ☐

Others (please specify)………………………………………………………………………………..

5. What type of disease surveillance data would you want to receive from other ICT staffs working for other organisation?

(a) Polio information ☐

(b) Malaria information ☐

(c) Ebola Information ☐

(d)HIV/Aids information ☐

(e) Cancer Information ☐

(f) Epilepsy Information ☐

Others (please specify)………………………………………………………………………………

6. When accessing disease surveillance data how long does it take you to receive the information from other ICT Staffs who works for other organisations?

(a) Within a day ☐

(b) Between 1-5 weeks ☐

(c) Between 5 – 10 weeks ☐

(d) Between 10 – 15 weeks ☐

Others (please specify)

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7. What is the status of semantic interoperability of Health information system (HIS) in Namibia?

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8. How to do you communicate disease surveillance data to another ICT staff member

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9.Why do communicate in that way?

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10. For how long does it take to receive and access such information?

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11. How do you get data in another Health information system deployed in another department?

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12. Why do you use such methods?

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