Arab American University-Palestine

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‘‘Towards Secure Interoperability Electronic Health Record among Healthcare Organizations in Palestine’’

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Thesis Approval

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This thesis was defended successfully on 3/9/2022 and approved by:

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2- Dr. Mohammad Awad	
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Dedication

To my beloved parents; the reason for what I became today; they gave me lessons in otherworldly things,

To my cherished sisters and brother,

To my wife and children,

To my friends and colleagues in the Ministry of Telecommunications and Information Technology,

To my supervisors and all who bolstered me in finalizing this work,

To those who made my thesis happen.

And most especially to our Almighty Lord our God.

This research is dedicated to you.

Acknowledgments

"I would like to express my thankfulness to Almighty God who remains to give me his benedictions for studying.

I would like to express my deep gratitude to the Arab American University and to the Department of Health Sciences for providing me with such a great opportunity.

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I'm very grateful to my family, teachers, and colleagues for their encouragement, inspiration, love, and support throughout the entire duration of my study".

ABSTRACT

The development of Information and Communication Technology (ICT) in the world is constantly increasing in the various fields of e-health, which contribute to facilitating and developing healthcare, simplifying procedures, and improving the quality of healthcare, which is positively reflected in patients, physicians, and healthcare providers. E-Health suffers from the problem of interoperability between different healthcare institutions, to share and exchange Electronic Health Records (EHR). Healthcare centers in Palestine have different health information systems, which has made sharing health information more difficult and complex. In developed countries, many frameworks and systems support interoperability between health care institutions according to international standards that guarantee privacy and security. It will surely provide many great benefits for all stakeholders (physicians, patients, and healthcare providers).

This research aims, firstly, to investigate the current status of electronic health records accreditation in Palestine, in addition to the readiness of the various healthcare centers to achieve interoperability, and secondly to propose an appropriate technical framework for interoperability, which achieves the secure exchange of electronic health records between the various health care institutions in Palestine.

The mixed method approach (qualitative, and quantitative) was used to achieve the objectives of the research, where the qualitative results based on interviews with information technology specialists in many private and public healthcare hospitals in Palestine, revealed that the health systems used in private institutions differ from health systems in public institutions, in addition to the consensus of all Interviewees on The necessity of achieving interoperability, the challenges of interoperability were discussed, including security,

privacy, high costs, and the lack of adequate infrastructure, in addition to the lack of necessary standards for interoperability. Interviewees were consensus about the need for a decentralized environment for interoperability in Palestine, unanimity on the importance of interoperability and its great benefits for patients, physicians, and health care providers, there is also consensus that ICT is capable of achieving secure interoperability. The quantitative results through the analysis of the questionnaires showed the challenges and benefits of interoperability in addition to the technical and informational interoperability requirements. The analysis indicated the great benefit of interoperability for patients and stakeholders from the point of view of health workers and their support for its achievement in Palestine, in addition to the challenges of interoperability. Quantitative and qualitative studies confirmed that there is no electronic exchange of electronic health records between private and public health care centers, and stressed the need to achieve interoperability to improve the quality of health care in Palestine and keep pace with the world in health technology development.

Based on these results, the researcher proposed a framework for secure interoperability in Palestine owned by the Palestinian Ministry of Telecommunications and Information Technology, called (UXP/XROAD) to share the EHR in a standard format that computers and various applications can use.

Keywords: Interoperability, eHealth, eHealth, Standards, ICT, Infrastructure, UXP/XROAD.

Declaration

I hereby declare that I am the sole author of this thesis.

I acknowledge that what was included in this thesis is the product of my effort, except for what has been referred to, wherever it is mentioned, and that this letter as a whole, or any part of any other educational or research institution to whom it has not been submitted before for a degree or scientific or research title.

I am the undersigned submitter of the thesis with the title:

"Towards Secure Interoperability Electronic Health Record among Healthcare Organizations in Palestine"

Signature: 

Date: **28/11/2022**

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Acronyms and Abbreviations

API	Application Program Interface
CDC	Centers for Disease Control
CDS	Clinical Decision Support
CPT	Current Procedural Technology
E-GOV	E-Government
EHR	Electronic Health Record
EMR	Electronic Medical Record
HHS	Department of Health & Human Services
FHIR	Fast Health care Interoperability Resources
HI	Health Information
HIE	Health Information Exchange
HIMSS	Healthcare Information Management Systems Society
HIPAA	Health Insurance Portability and Accountability Act
HIT	Health Information Technology
HL7	Health Level 7
ICD	International Classification of Diseases
IT	Information Technology
OIS	Office of Interoperability & Standards
PHC	Personalized Health Care
PHR	Personal/Patient Health Record
SNOMED	Systematized Nomenclature of Medicine

SSL	Secure Sockets Layer
TLS	Transport Layer Security
DICOM	Digital Imaging and Communications in Medicine
ISO	International Organization for Standardization
ICT	Information and Communications Technology
MTIT	Ministry of Telecommunications and Information Technology
MoH	Ministry of Health
CDA	Clinical Document Architecture
XML	Extensible Markup Language
XROAD	Data Exchange Layer
UXP	Unified eXchange Platform
SPSS	Statistical Package for the Social Sciences
XSL	Extensible Stylesheet Language
EMRAM	Electronic Medical Record Adoption Model
IEEE	Institute of Electrical and Electronics Engineers
OOP	Object-oriented programming
SQL	Structured Query Language
JSON	JavaScript Object Notation
SCSI	Small Computer System Interface
PCI	Peripheral Component Interconnect
IDE	Integrated Development Environment
HTML	HyperText Markup Language

LONIC	Logical Observation Identifiers Names and Codes
DDBS	Distributed Database System
P2P	Peer to Peer
SSO	Single Sign On
WHO	World Health Organization
SDO	Standards Development Organization
CPOE	Computerized Practitioner Order Entry

Chapter 1: INTRODUCTION

1.1 Overview

In the EU, Australia, Canada, Hong Kong, and most developed countries, prescriptions and electronic health records are shared across various interoperable networks and systems (HIMSS, 2022).

Medical consultations in one EU country, conduct medical lab and radiology tests in another country and dispense their medications in a third country. A medical patient summary provides physicians with basic information about a patient's health condition. This virtual network includes all healthcare providers across Europe (HIMSS, 2022).

Argentina's National Interoperability Network uses the standards to enable communication between participating health information systems, provide a bridge for sharing documents and patient summaries, manage electronic descriptions and support national records (HIMSS, 2022).

Information and Communication Technology (ICT) has positively affected different fields of health systems in most countries of the world by improving health care in its various aspects, such aspects include reducing the cost of health care services, increasing the quality of the services, and reducing the time required to perform the job (Olaronke, Soriyan, Gambo, & Olaleke, 2013; Shahmoradi & Habibi-Koolaee, 2016).

The transition from traditional records (paper and others) to electronic records is not an easy process in the health sector, because the electronic transformation requires a lot of effort by health care providers, doctors, and patients to achieve (Majeed, 2010). However, electronic health records provide many services and facilities for better health care. The electronic health record (EHR), is an electronic version of a patient’s medical history, that is maintained

by the provider over time, and may include all of the key administrative clinical data relevant to that person's care under a particular provider, including demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports, The EHR also can support other care-related activities including evidence-based decision support, quality management, and outcomes reporting. (CMS, 2021).

Healthcare providers in Palestine relied on independent electronic systems, and this independence is the reason for the difficulty of interoperability between health information systems in most countries. In many developed countries such as the United States and many European countries, interoperability between these systems has been established and a unified electronic registry has been established. (Olaronke et al., 2013; Shahmoradi & Habibi-Koolaee, 2016; Majeed, 2010)

In Palestine, there have been many efforts to establish a health information system to manage electronic health records among health care institutions according to the globally used standards for electronic information exchange, such as Health Level 7 (HL7) and Clinical Document Architecture (CDA), but there are still significant obstacles and challenges (El Jabari, Macedo, & Al-jabari, 2020).

In July 2020, El Jabari, Macedo, and Al-Jabari proposed a conceptual model to make interoperability between healthcare institutions through blockchain technology, considering the importance of privacy and security, but the lack of proper infrastructure and the lack of policies and healthcare standards for exchange health data requires huge efforts prior applying this model. (El Jabari, Macedo, & Al-jabari, 2020).

In this research, we will focus on the interoperability in private and public health centers in Palestine, in addition to proposing a framework for interoperability between healthcare institutions, from the concept of information technology and the possibility to share and exchange different medical and clinical information in different places, as well as taking care of security and privacy of exchanged data. Since interoperability is the basic building block in increasing the quality of health care and reducing costs effectively, this research will provide a deep understanding of the current scenario as well as provide a future vision at the level of Palestine to help provide a feasible solution for interoperability among health care institution in Palestine.

For a good proposal of an interoperability framework, the framework should be easy because the electronic transformation requires a lot of effort by health care providers, doctors, and patients to achieve using a secure e-government channel (El Jabari et al., 2020). This will help secure the system and will generate a privacy-preserving interoperability framework between different health care systems in private and public health care (represented by the Ministry of Health).

1.2 Justification and Significance of The Study

The importance of the research arises from the importance of the electronic health record and its availability at every time and to all relevant healthcare providers. The medical record contains medical, demographic, and personal information for the patient, and obtaining medical information at the right time and place will effectively reduce medical errors, as well as speed up the treatment of patients by helping doctors to take the appropriate decision. Furthermore, it will reduce the cost of health services, and this will generally lead to

achieving the goal of improving and developing the quality of health care in health care institutions in Palestine (Majeed, 2010).

Maintaining the privacy and confidentiality of health data, in addition to the lack of policies and standards to exchange health data electronically in Palestine, is one of the most important challenges and obstacles to interoperability. These challenges prevent and negatively affect the customers' trust in health care providers in the field of electronic interoperability.

The research presents a framework for interoperability between Palestinian health care institutions by ensuring privacy and security for the exchange of various health data through an electronic system controlled by the Palestinian Ministry of Telecommunications and Information Technology (MTIT). In this research, we seek to exploit the MTIT existing system to achieve interoperability between health care institutions in Palestine. Hence, this proposal will strengthen the position of the Palestinian government by setting policies and standards and making MTIT a controller of the whole system players, which will make our health partners trust the proposed system.

Benefiting from the conclusions and recommendations of the research is important to determine the procedures and capabilities and unify efforts in all health institutions with the support of the Palestinian government to reach secure interoperability among all health institutions in Palestine, which in turn leads to improving the quality of health care services in Palestine.

The exchange of medical information can open new horizons and cooperation among medical centers. Therefore, in the future, this vision can be effectively measured as an essential building block for high-quality, low-cost healthcare services. This thesis will explain the

benefits and challenges in achieving interoperability between public and private healthcare centers. The integration and exchange of information between different healthcare providers bring the chain of treatment and bridge the interoperability gap between healthcare institutions. We will propose a solution in the current situation, the solution will be proposed by first deeply understanding the scenario of linking health care institutions in Palestine through a clear framework of the process of linking these institutions by adopting security standards and maintaining the confidentiality of the information being shared.

1.3 Problem Statement

In Palestine, where private hospitals work on health information systems that are different from each other and different from the health information system used in the public health sector, for this reason, there is no immediate electronic data exchange between these institutions, and this negatively affects the quality of health care in Palestine. Health information is valuable, accurate, and highly private, therefore, it is necessary to apply strictly all security and privacy measures so that the system complies with approved international standards.

The researcher will propose a framework with an acceptable level of interoperability (semantic level), where two or more systems can exchange information, and the information can be used. The framework will satisfy well-known security and privacy standards and will be centrally controlled by MTIT. To sum it up, the thesis aims to evaluate electronic systems and infrastructure in public and private health institutions in Palestine and determine challenges, benefits, and obstacles, and then propose the appropriate framework for interoperability.

1.4 Interoperability Framework

The researcher is working on a secure framework within the capabilities available in Palestine for interoperability among private and public healthcare institutions, by linking the various healthcare institutions using the secure Palestinian Interoperability System (XROAD) owned by the Palestinian Ministry of Telecommunications and Information Technology (MTIT, 2022).

XROAD system enables us to use the highest security standards required for health information that will be exchanged between different healthcare institutions by encrypting the data that passes through it. The system is considered one of the most powerful data exchange and protection systems in the world, and the Palestinian government uses it to implement the concept of e-government through the interoperability of various government institutions and the exchange of data among them since 2011. XROAD is used as a decentralized system for data exchange, and the data remains the property of the health institution providing it, but the data is shared through the Application Programming Interface (API) without saving it anywhere and we can use it through the databases of the health institution providing the data (MTIT, 2022).

1.5 Research Questions

The purpose of this research is to survey and address the following research questions:

1. What is the current state of interoperability in the private and public healthcare sectors?
2. What are the obstacles to interoperability in the private and public healthcare sectors?

3. What is the compatibility level of interoperability between the private and public healthcare sectors?
4. What better framework will satisfy well-known security and privacy standards for interoperability of healthcare sectors in Palestine?

1.6 Aims

This research aims to assess the capabilities of private and public care centers in Palestine to implement interoperability among their health information systems and propose a framework that will satisfy well-known security and privacy standards and implement interoperability among their health information systems.

1.7 Objectives

- To determine the current state of interoperability in the private and public healthcare sectors.
- To explore the obstacles to interoperability in the private and public healthcare sectors?
- To determine the compatibility level of interoperability between the private and public healthcare sectors?
- To achieve a better framework that will satisfy well-known security and privacy standards for interoperability of healthcare sectors in Palestine?

1.8 Thesis Outline

The thesis structure is organized as follows; the first chapter provided an introduction and background on interoperability and its importance for improving healthcare services and increasing healthcare quality. It also described the research problem and objectives. Chapter

two is covering the theoretical framework for research in terms of definitions, roles, and services, then explains the levels of interoperability, challenges, and benefits. It is also talking about the possibility of interoperability in Palestine and the standards used in interoperability globally, and it also explains the research methodology and framework that is proposed in this research to achieve interoperability in Palestine from a technical aspect. Then the third chapter discusses the literature review on interoperability between health care centers at the local, regional and global levels. Then, in the fourth chapter, the methodology, questionnaire, interviews, sources of collected information, and identification of the research population and sample were discussed, in addition to the study period and study tools, and then the validity of the questionnaire is discussed as well. Chapter Five presents the results of the analysis of interviews and questionnaires in all its sections and clarifies the characteristics of the sample. The sixth chapter presents the framework proposed by the researcher for interoperability in Palestine, clarifies the protocols used and the security level of the framework, and presents an experimental framework for interoperability. Finally, chapter seven presents the discussion, limitations, strengths of the study, and conclusions and recommendations as well.

Chapter 2: THEORETICAL FRAMEWORK

2.1 Introduction

In this chapter, we present the theoretical basis for electronic health records, the role of Information Communication and Technology (ICT), and E-health services regarding patient information that includes, E-prescription services, Electronic Medical Records (EMR), Electronic Medical Record Adoption Model (EMRAM), Electronic Health Records (EHR), Interoperability, Syntactic and semantic Interoperability, Challenges to interoperability among healthcare centers, Benefits of Interoperability, Interoperability among Palestine Healthcare, achieve of Interoperability among different Healthcare Organization, Health Level Seven (HL7), Clinical Document Architecture (CDA), Peer to Peer paradigm, and Unified eXchange Platform (UXP) OR X-ROAD in Palestine.

2.2 E-Health

The concept of e-health is one of the most important concepts in the field of health in the modern era. The use of information and communication technology to support and improve health outcomes through e-health has the potential to change the way health services are provided (6). The term e-health contains many tools and applications and deals with various events and jobs in addition to the association with medical informatics, public health, and business, through which various health care services can be provided and medical information is communicated locally, regionally, and globally using various communication and information technology techniques (Majeed, 2010).

E-Health was defined by G Eysenbach, as e-health an emerging field in the intersection of medical informatics, public health, and business, referring to health services and information delivered or enhanced through the Internet and related technologies (Eysenbach, 2001).

2.3 Role of Information Communication and Technology (ICT)

ICT has provided many different platforms to improve patient health care systems and help health care stakeholders and decision makers to provide better services to citizens. Also, the main advantage of the ICT platform is that patients, doctors, and medical personnel will obtain medical information through the Internet from anywhere, and this makes patients satisfied with the service, and helps health care professionals in accessing information through a single interface and from multiple sources.

Health systems infrastructure is being developed in many countries including Palestine; The Ministry of Telecommunications and Information Technology (MTIT) and the Palestinian Ministry of Health (MoH) are working to update and develop storage systems, networks, and electronic infrastructure, which can be used in managing and storing Health information in Palestinian health institutions in a secure pattern. As a result, this will enhance the possibility of interoperability between the various healthcare institutions in Palestine by having some infrastructure deployed.

The national strategy of the Palestinian Ministry of Health has clarified the importance and support for the implementation of e-health and telemedicine programs. And among the medium and long-term national health priorities is the need to work on keeping pace with health technology and e-health applications through strengthening the health monitoring system for epidemics and infectious diseases, electronic monitoring, linking with

Laboratories and civil records, promoting and supporting the application of e-health programs, telemedicine, e-health education, computerized health monitoring, and others. These priorities establish a basis for developing a suitable infrastructure that might be easily adapted to be used in interoperability among different healthcare institutions (Ministry of Health, 2021).

2.4 E-Health Services Regarding Patient Information

E-Health provides many services to citizens and patients, the following are some of these services:

2.5 E-Prescription Service

When different patients come to different Palestinian health centers (private or public) to obtain their medical prescriptions, and due to the lack of interoperability environment among Palestinian health care institutions, it is impossible to obtain these electronic medical prescriptions. This might result in some problems for patients such as missing their prescription paper or even the inability to pinpoint mistakes or contradictions between prescribed medications. Achieving interoperability between the different care institutions will make it easy for the citizens of the State of Palestine to obtain electronic prescriptions at any time or place and with better flexibility and trust.

2.6 Electronic Medical Records (EMR)

The Electronic Medical Record (EMR) refers to everything that you can find in the paper chart, such as medical history, medications, diagnoses, dates of vaccinations, immunizations, and allergies that are stored electronically. While electronic medical records work well inside the institution, they are limited and do not travel outside the scope of the institution. If it is

required to share some EMR data with outside institutions, then the electronic health record can be printed and sent by mail in a hardcopy status (HIMSS, 2022). A broader concept is called Electronic Health Record (EHR), through which the electronic medical record can be contained, and which provides us with the possibility of sharing data electronically between health care institutions.

2.7 Electronic Health Records (EHR)

The electronic health record is the foundation of the scope of electronic health. Electronic health records are digital versions of a patient's paper medical records. These are real-time records that focus on the patient and provide information instantly and securely to authorized users. Electronic health records contain patients' medical and treatment histories, Medications, diagnoses, vaccination appointments, treatment plans, radiographs, allergies, and lab results. It allows access to evidence-based tools that providers can use to make appropriate decisions about patient care (HealthIT.gov, 2019).

One of the main advantages of electronic health records is that health information can be created and managed by health care providers using a digital format that can be shared with different health service providers from hospitals, health centers, laboratories, specialists, pharmacies, medical imaging facilities, emergency clinics, and workplaces. Hence, it contains information from all doctors and specialists involved in patient care, and this helps in the interoperability of patient data among health care institutions in different health centers, and this leads to multiple accesses to a single electronic record for the patient (HealthIT.gov, 2019).

2.8 Electronic Medical Record Adoption Model (EMRAM)

The Electronic Medical Records Accreditation Model (EMRAM) is used to assess the implementation of electronic health records and technology adoption for hospitals and health systems, and to guide the data-driven progress of care in inpatient care facilities in the health system through EMR (HIMSS, 2022).

It consists of eight stages from 0-7 that are used to measure the adoption and the use of electronic medical records functionality. A brief description of the EMRAM stages is below: (HIMSS, 2022).

Stage 0: The organization has not installed all the major ancillary department systems (laboratory, pharmacy, cardiology, radiology, etc.

Stage 1: All major clinical ancillary systems are installed, and business resilience plans are developed for each ancillary system describing how to communicate the scope and duration of the outages and distribute outcomes as needed.

Stage 2: Clinicians have access to the CDR to review the results. IT Change Management involves reviewing proposed changes and having a rollback plan before the change is made.

Stage 3: More than 25% of clinical documents are generated using online tools and available to clinical team members in the Clinical Data Repository. Access to external data sources. Infrastructure for bedside point of care scanning is planned or installed in some but not all locations. Manage appropriate access to documents based on the role of staff. Scheduled outages are communicated including affected areas and duration.

Stage 4: More than 50% of all medical orders are placed using a Computerized Practitioner Order Entry (CPOE) by any physician authorized to create applications. During the EMR downtime, clinicians can access a patient's allergy, list of problems/diagnoses, medications, and lab results. Patient satisfaction targets are defined for each clinical program and specific patient population. The Clinical Governance Committee evaluates the effectiveness of computerized orders.

Stage 5: More than 75% of clinical documents are generated using online tools and available to clinical team members. In the Clinical Data Repository. More than 25% of medications are identified electronically at the bedside. Enables the ability to integrate documents from external sources into a clinical data repository, and use code to create external data available to physician teams. Clinical Governance evaluates the effectiveness of the CPOE and approves changes to workflow to improve staff efficiencies.

Stage 6: It enables structured or coded data from external sources to be integrated into a clinical data repository. Measuring patient satisfaction using automated digital tools. The Analytics governance actively evaluates the results data for changes that are needed and available in a common repository. Formation of a Clinical Governance Committee to identify priorities for quality and care.

Stage 7: Improving patient safety through the implementation of electronic health records to access information in the right place and time. Increase Patient Satisfaction - Reduce time and errors in healthcare delivery. Support Clinicians - An effective electronic health record is designed for the distinct uses of the clinicians who work with it. Secure Data - Effective hospital data security policies and governance are critical components of the successful

implementation of electronic medical records, for the appropriate use of data stored by electronic medical records and the level of access available to clinician teams and others within the organization

2.9 Interoperability

“Healthcare information interoperability is the ability of health information systems to work together within and across organizational boundaries. (HealthIT.gov, 2013)” The target systems must adhere to agreeing on the type of data that will be exchanged and agree on interoperability standards between all parties. The systems inevitably cooperate to exchange complete information only in the event of integration between the various institutions. Interoperability is a broad concept, and many have been suggested among the definitions of interoperability in academic and industrial fields, in this thesis, we study interoperability between public and private healthcare institutions in Palestine, and this section provides a brief overview of the technical, syntactic, semantic and organizational aspects of interoperability (Lehne, Sass, Essenwanger, Schepers, & Thun, 2019; Majeed, 2010).

Following are the important interoperability definitions according to IEEE, Interoperability is the ability of two or more systems that are used to exchange information and to use this information that has been exchanged.

In the field of eHealth applications ―that means the ability to communicate and exchange data accurately, effectively, securely, and consistently with different information technology systems. (Majeed, 2010).

The Healthcare Information and Management Systems Society (HIMSS) Board has established a multi-layered framework to help medical professionals assess data exchange and document management capabilities. While reviewing levels, the interoperability of healthcare institutions can be assessed. An assessment of current capabilities and limitations helps to establish and develop a clear path for improvement, ensuring the best possible productivity, and better outcomes in patient care (Rick, 2022).

Healthcare interoperability uses timely and secure access to electronic health data that can be used to improve health outcomes for individuals and populations. It also allows physicians, patients, and health workers, each according to their specialization, to access the patient's health information according to their authorization levels and access rights.

2.10 Levels and Layers of Interoperability

There are three levels used to solve the interoperability problem, they include interoperability at the content level, interoperability at the physical level, and interoperability at the specification level. Each of these levels has also two layers of interoperability, namely: semantic interoperability and syntactic interoperability. These levels are distributed according to the interoperability problem and may be related to each other. Syntactic and semantic interoperability must be involved at almost all levels because any interoperability problem requires recognition of the same information delivery on the interface (Majeed, 2010).

2.11 Levels of Interoperability

In this section, the three levels of interoperability, physical, content, and specification levels, are explained:

❖ **Physical Level Interoperability**

According to this level, electronic media such as flash memory, hard disk, floppy disks, chip cards, magnetic tapes, and other various electronic media are used, to achieve the possibility of interoperability by physically transferring information, concerning this level Information is transferred manually between different applications and institutions. First, the information is stored in the actual media from the first application, and then it is entered as input in the other application. This type of interoperability has a high level of difficulty that is often solved by electrical engineers, as well as the adoption of some standard storage with the efforts of computer scientists to overcome the problem of storage (Majeed, 2010).

❖ **Content Level Interoperability**

This level is related to the structure and content of data that will be exchanged between different systems. Content level interoperability focuses on designing schemas and frameworks that lead to the design of databases necessary to solve problems. It requires data coordination appropriately so that we can use the data used by a single application on a device such as ECG by a different application on other devices. In another way and more specifically the content level interoperability is related to the standard level and to certain standards such as (HL7), usually homogeneous databases are used in this type of interoperability and the same formats for data storage. Most solutions at this level are designed for database design (Majeed, 2010).

❖ **Specification level Interoperability**

Specific level interoperability can be achieved through an interoperable platform at a software application level based on heterogeneous databases. To provide solutions to this level, standards such as HL7 must be adopted, or we may use programming methods such as Object-Oriented Programming (OOP) for a distributed environment (Majeed, 2010).

2.12 Layers of Interoperability

There are two layers of interoperability:

1. Syntactic Interoperability.
2. Semantic Interoperability.

❖ **Syntactic Interoperability**

Referred to as syntactic interoperability, when two or more systems exchange data and communicate with each other, they show syntactic interoperability, and most importantly, the form of the data and the protocols used must be compatible between the systems (Majeed, 2010).

Syntax compatibility is generally achieved through Extensible Markup Language (XML), Structured Query Language (SQL), JavaScript Object Notation JSON, and syntactic interoperability are necessary for further new efforts towards interoperability (Majeed, 2010).

Extensible Markup Language (XML) "*is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. XML was designed to store data in a way that is much more human-readable. It is one of the most*

widely used data formats to store, send, and receive data." (Kaura, Ayyagaria, Mishrab, & Thukralb, 2020)

SQL (Structured Query Language) *"is a structured language for specialized purposes used to communicate with the data stored in a database management system."* (Nethravathi, Amitha, Saruka, Bharath, & Suyagya, 2020).

JavaScript Object Notation (JSON) *"is a lightweight data-interchange format. It is easy for humans to read and write. It has a data format that is interchangeable with programming languages' built-in data structures that eliminates translation time and reduces complexity and processing time. Moreover, JSON has the same strengths as XML."*

- **Semantic Interoperability**

Semantic is referred to by meaning and expression, and thus semantic interoperability is concerned with "the ability of information systems to exchange information based on common, pre-defined and agreed upon meanings of terms and expressions. (Majeed, 2010)." Syntactic interoperability is a necessity of semantic interoperability, as this type of interoperability is to ensure that messages are correctly delivered to the data receiving party, i.e., acknowledgment of message delivery at the intended destination. Regarding the possibility of semantic interoperability, the aspect of semantic mediation plays an important role in the field of data collection through heterogeneous sources, the main objective of semantic mediation is to change the medical messages that have already been selected into a format that can be understood and handled by the data receiver (Majeed, 2010).

2.13 Challenges to Interoperability among Healthcare Centers

The main purpose of having interoperability between healthcare centers in Palestine is to exchange information among them. The most important of these data is the patient's electronic health record, this requires communication and harmony between health care centers in Palestine and integration among them. This communication and integration are important for interoperability (Majeed, 2010).

- **Interfacing**

  The boundary at which interaction occurs between two different systems or processes is called interfacing.

  In computer science terminology, there are three types of interfaces, the user interface provides human-computer interaction and can be graphic, audio, video, or text, depending on the underlying software and hardware, the hardware interface are the sockets, cables, plugs, and electrical signals that traveling through them, examples are Ethernet, USB, FireWire, Ethernet, SCSI, PCI, and ATA/IDE, and software interface are an example, a program interface defines the languages and symbols that applications use to communicate with each other (Majeed, 2010).

- **Integration**

  It is the integration of diverse applications in a relationship to act as a collaboration of many components of a system to form a single entity. Integration must include appropriate specifications, standards, and a communication platform that is likely to provide interoperability between healthcare organizations, or else the integration will not occur (Majeed, 2010).

❖ **Accessibility**

It is very important to focus on accessibility because when different health care institutions communicate with each other, we start by providing the appropriate capabilities to determine who can access the shared information and at what level a particular user can access medical information through the system according to specific authorization, so it is better to provide a way to access clinical information and the electronic health record through the systems (Majeed, 2010).

❖ **Privacy**

Privacy is one of the biggest challenges that prevent e-health service providers from gaining the trust of patients and implementing the e-health system and interoperability. Privacy is defined as the ability to facilitate or enhance core values such as personal or individual autonomy or human dignity, and it gives individuals control over how electronic health care information is managed and used by physicians and other users in health care and other fields. Once the information is accessed, a privacy issue appears (Bajrić, 2020). The information is accessed only by authorized users who have permission to use the system, and each user accesses specific information by the license granted to him. (Majeed, 2010).

❖ **Security**

To share patient medical information such as health records or clinical information of the patient himself and on other healthcare facilities must be following the Health Insurance Portability and Accountability Act (HIPPA); HIPPA act is applied in the USA only. Other acts are used in the EU and other countries. There is a need for a

similar act in Palestine to manage the security, privacy, and accessibility of patients' health data among providers and institutions. (Majeed, 2010).

Within the health care community, security and privacy are closely related, and sometimes the two are erroneously used interchangeably. Privacy is seen as protecting the independence of the individual and security is protecting the interest of the health organization, as it requires the secure interoperability of health care information within the same institution or between institutions. Therefore, electronic health record systems need to implement global security perceptions and standards that ensure physician roles, patient consent, and interoperable audit trails and records (Bajrić, 2020).

The most important federal law that required the creation of national standards used in protecting data during interoperability is the Health Insurance Portability and Accountability Act (HIPPA); There is a need for appropriate licensing and consent to interact with medical information, in particular, who will access patient data, when and at what level it may be accessed. All appropriate levels of security and ensuring that all systems provide adequate security (Majid, 2010).

The most important privacy and security challenges in electronic health care systems:

Access Control and Authentication

Access control to medical data is necessary to ensure appropriate authorization and confidentiality of patient records. Strong and reliable forms of authentication and standards are an important requirement to protect the privacy of patient records and are the first stage of the validation and identification process for users to ensure that

they are authorized to access the system. According to privacy rules, patients shall have full visibility of whether their health records can be used and for what purposes, the patient's participation in managing their health data is likely to improve privacy issues (Bajrić, 2020).

Data Integrity

Ensuring integrity is one of the most important keys in an electronic health record system, as it ensures data accuracy and thus reduces errors and improves patient safety. Miscommunication between paper and electronic health records, incorrect entry of information, or insufficient knowledge using information exchange protocols cause such errors to occur (Bajrić, 2020).

System Availability

Electronic health care continuity must be achieved for the best service delivery. For example, if the electronic system or network is down, health care providers will not be able to access patients' electronic data, so the availability of the network and information systems is critical. The infrastructure must be as per the recommended specifications of global interoperability, the system must be available at all times and places, or else the physician's job will be complex as decisions cannot be made in real-time (Bajrić, 2020).

Data Loss

In this context, because the storage of medical, personal, and confidential data is done using digital media, it is necessary to protect data from loss, network dangers, electronic attacks, and hacking by providing backup copies of data as well as implementing all of the necessary data preservation and protection measures such as

a firewall, antivirus, and many other protection procedures according to international standards (Bajrić, 2020).

Network Security

Data protection becomes critical when critical assets depend on network security. Disabling network functions, for example, denial-of-service attacks, can have a significant impact on healthcare delivery, as firewalls are one of the most common network security technologies, and the use of a network firewall is a very successful method for keeping an organization's network and maintain health information as secure as possible (Bajrić, 2020).

2.14 Benefits of Interoperability

By achieving interoperability among different healthcare organizations, the patient and healthcare professional can obtain fruitful medical information. By adopting interoperability, the patient can know his health status at any time easily by obtaining medical information from medical centers and institutions at the appropriate time and place, and these records can be adjusted through the certain authorization of the patient or health care providers and health care professionals (Majeed, 2010). Because of the interoperability, patients can easily travel between different healthcare centers without thinking that information may be lost or destroyed. Many benefits can be achieved through interoperability, some are listed below:

- Establishing a unified electronic health record for the patient that includes all the patient’s health information in public and private health care institutions.

- The citizens can obtain great benefits through agreements and regulations between health care providers in various fields.
- There will be the possibility for patients to access e-health services at any time and any place if they request it.
- There will be a reduction in the cost of health care if interoperability is achieved between private and public health care institutions in Palestine.
- Reduce time and effort in obtaining health information.
- Improving and increasing the quality of health care services in Palestine.
- The citizen will be able to access and share his health information even if he travels outside the country (Majeed, 2010).
- Safety of patient care will be better guaranteed.
- More accurate diagnosis
- Reduce duplication of lab and imaging tests.
- Preventing drug-drug interactions.
- Reduce time in patient sessions
- Improving decision-making.
- Avoiding filling out multiple forms
- Reducing health care costs
- Improve the reputation of hospitals and clinics.

2.15 Interoperability among Palestine Healthcare Centers

Palestine has been under Israeli occupation since 1948, which in turn worked to separate the Palestinian territories from each other, and Palestine is still divided into two parts, West Bank and the Gaza Strip. This division affected many areas including economic, health, and

political life. Besides, the successive wars on the Gaza Strip led to an increase in the number of sick and wounded from the remnants of war. West bank has Israeli army checkpoints that impede and prevent the movement of citizens and ambulances, citizens are exposed to searches and sometimes are prevented from moving through these checkpoints. Besides, there is a huge diversification of private and public hospitals in most Palestinian regions and governorates. From this point of view, the idea of interoperability between health care gained greater attention and importance, and it aimed to reduce the problems related to the health sector, through the possibility of access to medical data, and data integration regardless of the geographical separation and the economic impact on citizens and various health care institutions in Palestine.

Patients' data is exchanged between the various health institutions in Palestine, using the paper system, then the electronic systems in the public sector, and then email, respectively, according to the results of the questionnaire.

The percentage of citizens who use modern technology tools in Palestine is high, as it is hard to find a house that is devoid of a computer or a mobile phone. These indicators are important to support and achieve interoperability between health care institutions in Palestine, according to the Palestinian Central Bureau of Statistics in 2019 [1].

Table 2.1: Statistics of the information society in Palestine [1]

Indicator	Year	Value
Percentage of Households That Have Fixed Telephone Line	2019	31.2
Percentage of Households That Have Mobile Phone	2019	97.3
Percentage of Households That Have SmartPhone	2019	86.2
Percentage of Households That Have Computer (Desktop, laptop, tablet)	2019	33.2
Percentage of Households That Have Internet Access at Home	2019	79.6
Percentage of Individuals (18 years and Above) Who Use the Internet	2019	72.2
Percentage of Individuals (18 years and Above) Who Own Smart Phone	2019	72.8

2.16 Achieve Interoperability among Different Healthcare Organizations

Referring to the interviews with officials of information technology departments in private and public research hospitals in Palestine, the results showed that, it is very difficult in Palestine to achieve interoperability between private and public health care institutions

[1] https://www.pcbs.gov.ps/site/lang__en/881/default.aspx?lang=en

because each private institution uses a different health information system, hence the systems are complex work separately. However, governmental hospitals in West Bank use a central shared database that is, making the task in the process of interoperability between public health care institutions achieved by design. Since we have many private health care institutions in Palestine that use different health information systems, the problem of interoperability appears in the lack of interoperability between these systems, and also between any private and public institutions. Because of this, medical information cannot be shared among health care centers in private and public health in Palestine. Generally speaking, it is not easy to deal with clinical information because it is collected in a complex way using different complex health information systems.

The deviation of health information systems used in Palestine and the applications of these systems led to different methods and technologies that are used to store data and access databases. This in turn made it difficult to deal with data automatically and enforces us to resolve this issue using health standards. One of these globally adopted standards is Health Level 7 (HL7) which can be used efficiently to achieve interoperability between different health care centers in Palestine.

To summarize, interoperability makes it easier for different health centers in Palestine to access patient information at the moment they arrive at treatment centers and at the right time. This will save time, and cost, and will also help make the best clinical decision upon the availability of required information. The patient needs to have the medical information with him, and the difficult task of health care centers in the absence of information at the right time and place, affects the safety, cost, and effectiveness of health care. Besides, Health

care centers include dissimilar information, so problems arise in the data that is exchanged in the absence of standards to ensure the integrity of this data, so the use of standards in health information systems reduces interoperability problems.

2.17 Health Level Seven (HL7)

The HL7 standard is used for data management and integration, and it makes it easier for healthcare providers to provide many services, as HL7 provides standards for interoperability between different healthcare institutions, these standards enhance workflow and exchange of Electronic Health Records (EHR)s, and reduce the ambiguity of information about interoperability, how it is implemented and the procedures followed by health care providers. The HL7 standard defines the different guidelines, methodologies, and standards that healthcare organizations use to share health data. These standards allow different applications to share clinical information and help promote interoperability (Health Level Seven International [HL7]). HL7 has seven stages in its development life cycle as described below:

1. Defines the standard system integrations and compliance methods. These are the primary standards and possibly the most popular among the categories (Health Level Seven International [HL7]).
2. States the foundational standards that users can build and helps define the standards and technology infrastructure they plan to use (Health Level Seven International [HL7]).
3. Helps link messaging and document standards for providers (Health Level Seven International [HL7]).

4. Details how electronic health records (EHR) are constructed and managed using profiles and models (Health Level Seven International [HL7]).
5. Outlines the methods used for implementation and includes support documents for other categories. This section may also serve as the supplemental section for other standards categories (Health Level Seven International [HL7]).
6. Explores the rules and references used to develop programming structures for software and aids in standards development as well (Health Level Seven International [HL7]).
7. Educates users and provides the tools to help aid in the development and adoption of HL7 standards (Health Level Seven International [HL7]).

Implementing HL7 will enable the patient to visit many health care centers and hospitals with different health information systems, this is because different hospitals and different medical centers will be able to automatically communicate even though they have different structures and frameworks. Hence, HL7 standardization will enable the proposal of a comprehensive framework for sharing electronic health records, clinical information, message sharing, reports, etc., among heterogeneous health care information systems in Palestine.

HL7 has adopted the Reference Information Model (RIM), and there have been many versions of HL7. HL7 version 3 provides a standard that helps health providers match the information on a testable basis. This is achieved by enabling HL7 v3 messages to originate from RIM, and using the object-oriented methodology; where RIM explicitly provides the semantic and lexical meanings of messages exchanged through HL7 V3 (Majeed, 2010).

2.18 HL7 Clinical Document Architecture (CDA)

The Clinical Document Architecture (CDA) is a document markup standard that defines the structure and semantics of clinical documents for the exchange and sharing of patient data. The standard was developed by health level 7 (HL7), a standards development organization, focused on the healthcare field. There are two currently approved versions of the health document structure, CDA Release1 (CDA R1) approved in 2000 and CDA Release2 (CDA R2) in 2005, both versions are part of the new generation of HLV Standards Version 3, all of these versions were derived from the core Reference Information Model (RIM) that ensures semantic consistency across standards for various purposes such as pharmaceutical, laboratory, caregiving, etc. RIM is based on common vocabulary and data types and together these components make up the HL7 V3 foundation which is one of the foundations of the CDA standard (Majeed, 2010).

According to, the clinical document has the following characteristics:

- Persistence: the clinical document continues to exist in an unaltered state for a period defined by local and regulatory requirements.
- Stewardship: the clinical document is maintained by a person or organization entrusted with its care.
- Potential for authentication the clinical document can be legally authenticated.
- Wholeness: legal authentication applies to the entire clinical document; it does not apply to parts of the document taken out of context.
- Human readability: the clinical document can be easily read and understood (Dolin et al., 2001; (Health Level Seven International [HL7])

The CDA contains the patient's clinical information, typical CDA documents contain medical image reports, discharge summaries, admission reports, pathology reports, physical reports, etc. The most common use of CDA is the exchange of health information between different healthcare institutions (Dolin et al., 2001; & Health Level Seven International [HL7]).

The target groups in the CDA standards are healthcare providers, departmental systems, healthcare IT vendors, dictation/transcription vendors, and EHR and PHR Systems (Health Level Seven International [HL7]). The CDA benefits are listed below:

- Supports data reuse in multiple applications
- Supports interoperability between different healthcare institutions,
- Supports the exchange of clinical information between health care institutions
- And supports the reuse of clinical data for quality control, patient safety, clinical trials, and public health reports

CDA is developed in XML that contains information in tags and the document is organized in a head and a body. The medical record is stored, supervised, and authenticated and other information and records related to clinical data are stored in cards. Document text may contain unstructured or structured content. The unstructured portion of the document on non-XML contents CDA documents contain usable external references such as sounds, images, hyperlinks, and multimedia as shown in (Fig. 2.1). The information in the document is parsed by HTML pages using an XSL style sheet for display, and any XML repository can store this information (Majeed, 2010).

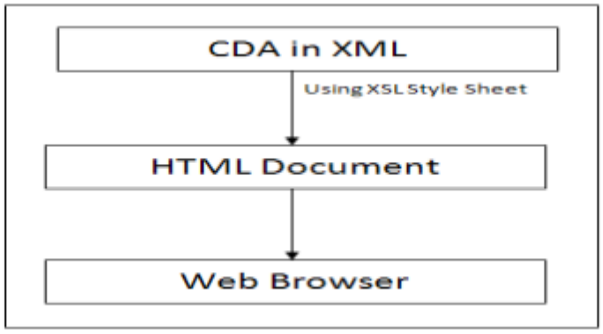

Figure 2.1: CDA document viewing (Majeed, 2010).

Different service providers have different ways to produce a CDA document and give output in CDA format, health care providers also convert the original data format to a CDA document. Semantics in a CDA document is a key concept of interoperability processing because it provides the user with knowledge of the level of interoperability interface to complete tasks and set their specification restrictions accordingly (Majeed, 2010).

A CDA document contains XML metadata and can contain a few fields. While the body can contain a few data like word, PDF, scanned image files, etc. Some applications like the decision support system can't translate the body part of the document. To overcome this, some standards have been proposed for metadata and display properties in a document so that they can be produced and categorized using some richly coded documents. The CDA document is translated using the HL7 RIM model and International Classification of Diseases (ICD), Current Procedure Terminology (CPT), Logical Observation Identifiers Names and Codes (LOINC), and Systematized Nomenclature of Medicine Clinical Terms (SNOMED) are used to translate the vocabulary (Majeed, 2010).

The ICD-10-CM (International Classification of Diseases, Tenth Revision, Clinical Modification), is a system used by clinicians and other health care providers to code and classify all medical diagnoses, procedures, and symptoms recorded in conjunction with hospital care and provide a level of details necessary for diagnostic specificity and morbidity classification (Tayla & Alex, 2018).

Current Procedural Terminology (ICD) is a set of medical codes used to report medical, surgical, and diagnostic procedures and services to entities such as health insurance companies, physicians, and accrediting organizations. It is used in conjunction with ICD-9 or ICD-10 during the electronic medical billing process (Kristen, 2018).

Logical Observation Identifiers Names and Codes (LOINC), is a standard for identifying medical laboratory observations, it was created in response to a demand for the electronic movement of clinical data. LONIC applies names and identifiers to more than 58,000 medical terms that can be maintained in an electronic health record (TechTarget, 2010).

SNOMED CT (Systematized Nomenclature of Medicine -- Clinical Terms) is a standardized, multilingual vocabulary of clinical terms used by physicians and other healthcare providers for the electronic exchange of clinical health information (TechTarget, 2010).

CDA has three levels that can be described as follows: (1) Level 1 of a CDA document is used for a simple, standard-based address that contains a simple body without additional functionality, (2) Level 2 of a CDA document gives a proportionate number of additional Level 1 functionality with the XML body and encoded subsections, and (3) Level 3 of a CDA document provides both the first and second level functions and some additional information

encoded and in the section part of the body(Majeed, 2010). Digital Imaging and Communications in Medicine (DICOM) is a standard protocol for managing and transmitting medical images and related data and is used in many healthcare facilities (Megan, 2018).

2.19 Distributed Computing

A Distributed Database System (DDBS), combines both network technology and database technology for computing, so that distributed databases are linked to nodes or systems located in different communicating locations and are linked to each other through the network. These nodes may be in different places or they can be in the same location as the building, the data is logically arranged, and it is linked to databases in a distributed environment over a network. In this type of computing, the user can access data not only through local databases but also through databases linked to different nodes across the network. In the modern era and with the development of technology, the distributed environment is more useful, especially when organizations work separately (Majeed, 2010).

2.20 Peer-to-Peer Paradigm

Peer-to-peer computing is a new field in the modern era, and it is distributed in nature, Peer-to-peer software includes a participatory mechanism whereby different participants share their resources and use each other's services. In P2P-based computing, there is an interest in integrating many resources and data to make the distributed system more reliable, where each participant or node is known as a peer, and each peer performs different roles. Nodes can receive data from another peer, provide data to another peer, or be forwarding data to a third peer (Majeed, 2010).

Figure 2.2 shows the conceptual framework of a peer-to-peer network.

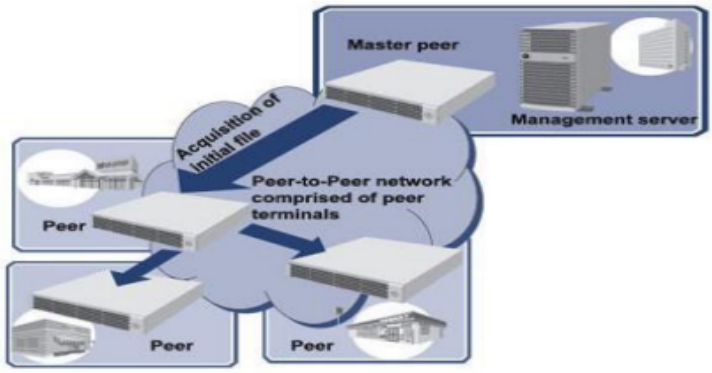

Figure 2.2: Conceptual framework of Peer-to-Peer network (Majeed, 2010).

2.21 Unified eXchange Platform (UXP) OR X-ROAD in Palestine

The Unified Exchange Platform (UXP), or X-Road, is a fully supported suite of software products that enable secure peer-to-peer exchange over encrypted and mutually authenticated channels that can be used to connect government records, organizations, and services (Cybernetica). Figure 2.3 shows the UXP architecture.

The UXP system was developed by the Estonian company Cybernetica, where the company developed more than one version of the system, and the old versions were called x-road for more than two decades (Cybernetica).

Key Benefits of UXP or X-ROAD

- All messages moving through UXP are encrypted at the highest reasonable grade
- All messages are digitally signed and timestamped
- Secure by design – UXP was created to function within the public internet, so its security has always been of a great importance
- UXP is a distributed technology – a fully decentralized
- Data owners have full control over all data and resources

- ❖ Full support and maintenance
- ❖ Auditability
    - o Fully transparent – every query sent over UXP becomes a document evidentiary value.
    - o Traceability – every transfer of data through UXP can be traced back to its source
    - o Transparency – easy to administer, easy to use.

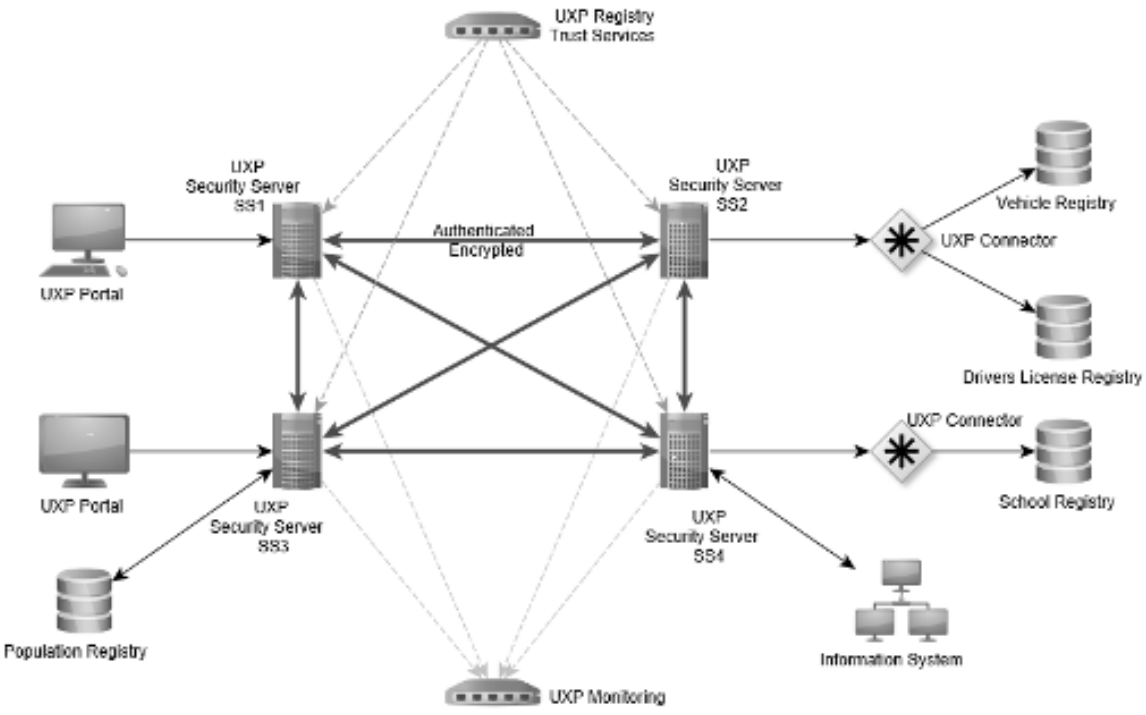

Figure 2.3: UXP Architecture

2.22 XROAD/ UXP Background in Palestine

The vision of the Palestinian government in 2010-2011 was to move from the traditional government to an electronic government. The first step in the project was the establishment

of the General Administration of the Electronic Government of the Palestinian Ministry of Telecommunications and Information Technology, as the government was in need to exchange data between various government institutions electronically in a safe manner. The government has purchased the x-road system from Estonia, through which data is exchanged between governmental institutions in Palestine securely, and more than 52 governmental institutions benefit from the systems and exchange data in between electronically.[2]

The Palestinian government has been working since 2019 on the e-government services portal, Single Sign On (SSO), and electronic payment through X-road, to automate all governmental services in one electronic portal. Citizens will benefit by saving their time and effort, and the government will have improved efficient financial systems. The system will be ready for release in a few months and people will be able to use it and gain benefits.

The main objective of presenting this system is to consider the possibility of using it in interoperability between health care institutions in Palestine, where the expertise and infrastructure necessary for secure interoperability are available through the Palestinian Ministry of Telecommunications and Information Technology.

2.23 XROAD Framework

The main objective of the proposed framework is to facilitate and speed up the sharing of electronic health records between private and public hospitals in Palestine, where data can be processed and coordinated by specialists in different medical centers before being shared. The framework focuses on achieving semantic interoperability using the latest security and interoperability standards and techniques used in the developed countries in the world. Using

[2] https://mtit.pna.ps/

the framework, it is possible to preserve patient privacy and determine the authorization of each part of data and its accessibility with the patient's consent, in addition to using the HL7 standard to coordinate clinical data in a standard format for exchange.

The framework focuses on linking healthcare centers among themselves for data integration; so the healthcare centers must be either a provider of medical data, a producer of medical data or both. Hence data can be shared between the different healthcare centers in Palestine, and to ensure their integrity. The framework is available in Palestine and is used by the Palestinian government and it supports the necessary tests to ensure data security by using internal testing systems at the Palestinian Ministry of Telecommunications and Information Technology. Besides that, the system works on the Internet which helps to connect all health institutions in Palestine, hence it helps to access information from any healthcare center easily and quickly. The XROAD system has a data recovery system outside Palestine, so, in cases of disasters and wars, the services don't stop in healthcare centers, except if the internet line is cut off. Moreover; if a problem occurs in one of the medical centers, it will not affect the other health centers and they continue to function efficiently.

XROAD/UXP collects data from health organizations, information systems, and databases and provides essential components for interoperability and data exchange in a secure and standardized method. XROAD/UXP allows service providers to control their systems and data while making them a member of a decentralized and infinitely scalable data exchange network. Data exchange is driven by the following properties:

Confidentiality of the Transferred Information, the direct communication between health institutions is encrypted, which is why there is no need for a central intermediary to intercept the data.

The Integrity of Data is assured by an elaborate mechanism for logging, timestamping, and digitally signing on all transactions and users of services.

Availability of Date. A distributed architecture eliminates potential bottlenecks, i.e. there is no central intermediary and the data is exchanged directly between members**.**

The XROAD/UXP system is used in many countries, including Japan, the USA, Ukraine, and Benin, it is used in many fields, including medical interoperability.

The researcher uses an XROAD/UXP framework to achieve interoperability between health care institutions in Palestine, which ensures the exchange of electronic health records while maintaining the security and privacy of the information so that this framework achieves interoperability from a technical point of view.

Figure 2.4 shows some countries that use XROAD/UXP in interoperability.

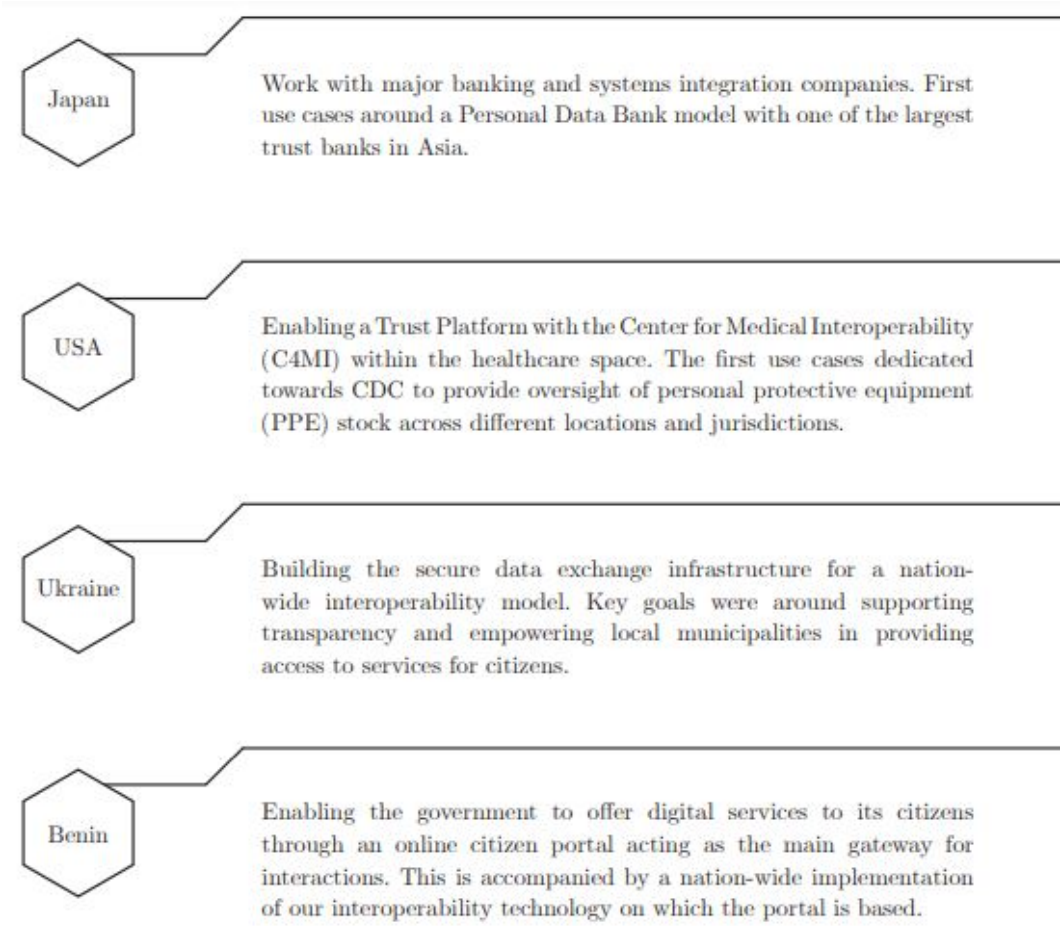

Figure 2.4: Some countries that use UXP/XROAD for interoperability[3]

2.24 XROAD/UXP REST/XML (SOAP) API's

REST is an architectural style consisting of the best practices and Guidelines (Petteri, 2020).

- In X-Road's case supporting REST means consuming and producing REST-style APIs via X-Road.
- X-Road's REST implementation supports transferring any content type over HTTP.

[3] Building Secure Data Exchange with Unified eXchange Platform: https://cyber.ee/uploads/UXP_Brochure_1283a6187c.pdf

- The message payload is transferred as-is, Security Server does not modify, convert or validate the payload in any way.

  X-Road REST Support:

  - Publish REST services with no changes to existing services.
  - Publish REST service descriptions using OpenAPI 3.
  - Consume REST services with minimal changes to existing clients.
  - No restrictions on supported content types.
  - Fine-grained authorization of REST endpoints.
  - Meta services for REST clients.
  - All standard X-Road features included, e.g. organization and machine-to-machine level authentication, logging, time-stamping, monitoring, etc.

Figures 2.5 and 2.6 show how messages are exchanged through the XROAD system using the SOAP and REST transport protocols, where the message is generated by the service provider and then payload to one of the mentioned protocols without any change or modification to the message until reaching the consumer of this message and using it (Petteri, 2020). Figure 2.5 shows X-Road REST.

Figure 2.5: X-Road REST (Petteri, 2020).

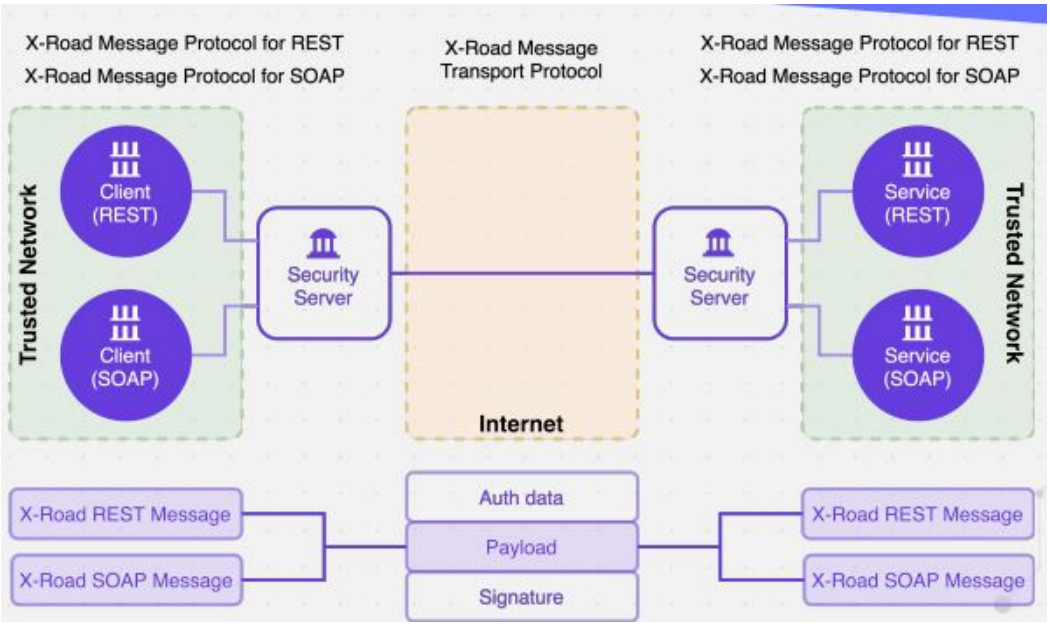

Figure 2.6: X-Road Message Protocols (Petteri, 2020).

XROAD/UXP uses Separate Message Protocols for SOAP and REST-style services, over HTTP:

- X-Road Message Protocol for SOAP
- X-Road Message Protocol for REST.

Transport message contains in place of the SOAP request part a more generic payload part that can contain SOAP, JSON, XML, etc. (Petteri, 2020).

Currently, X-Road has two message protocols: X-Road Message Protocol and X-Road Message Transport Protocol. X-Road Message Protocol defines how service consumers and service producers communicate with Security Server. The protocol is based on the SOAP profile and it comes with some X-Road specific limitations and additional requirements, e.g. support for synchronous request-response operations only, some mandatory SOAP headers required, and a document/literal style SOAP body required (Petteri, 2018).

The other part, X-Road Message Transport Protocol is a proprietary protocol that defines how Security Servers communicate with each other. The protocol uses HTTP 1.1 over TLS and MIME multipart framing. The protocol wraps the X-Road Message Protocol payload and adds some additional authentication data and message signature. The key limitation of the current implementation is that only SOAP payload is supported (Petteri, 2018).

2.25 XROAD/UXP Architecture

Figure 2.7 shows the architecture of the system that supports the framework proposed by the researcher, where data is exchanged between different healthcare institutions through it, and the use of the XROAD system requires that all healthcare centers are members of the XROAD system and have access to the XROAD entry point, the security servers required for the producing and consuming services, the security server mediates service calls and service responses between information systems, and it encapsulates the security aspects of the X-Road infrastructure; authentication and managing keys for signing, sending messages over the secure channel, creating the proof value for messages with digital signatures, time-stamping, and logging (Petteri, 2019).

XROAD logs contain all messages processed by the security server, each message is timestamped and signed which makes it possible to check the content of the message then by default the logs are stored locally by the security server and cannot be accessed by third parties (Petteri, 2019).

Both data consuming services and data sources are identified using X-Road globally unique X-Road identifiers. The identifiers contain information about the X-Road ecosystem, the member health organizations, and the information system consuming or producing data via X-Road. Identifiers are used internally by X-Road to routing messages between data using services and data sources. A data using the service does not need to know the network address of the data source, X-Road automatically assigns the service identifier to the correct network (Petteri, 2019).

2.26 XROAD/UXP Components

Figure 2.7 presents the components of the proposed framework:

- **Service Consumer**
    - Data request through e-portal
    - Security Server: To encrypt data.
- **Center Cervices**: Registration of all trusted parties (organizations, services)
- **Trust Services:** All requests go through to verify the access certificate, timestamp, login, and authentication.
- **Encrypted Data Bus**: To exchange encrypted data between two security servers.
- **Service Provider**

- Security server - (decrypts the requested data, validates it, and then encrypts the response data)
- Adapter server/connector server - (Query from database to create a response and pass to security server).

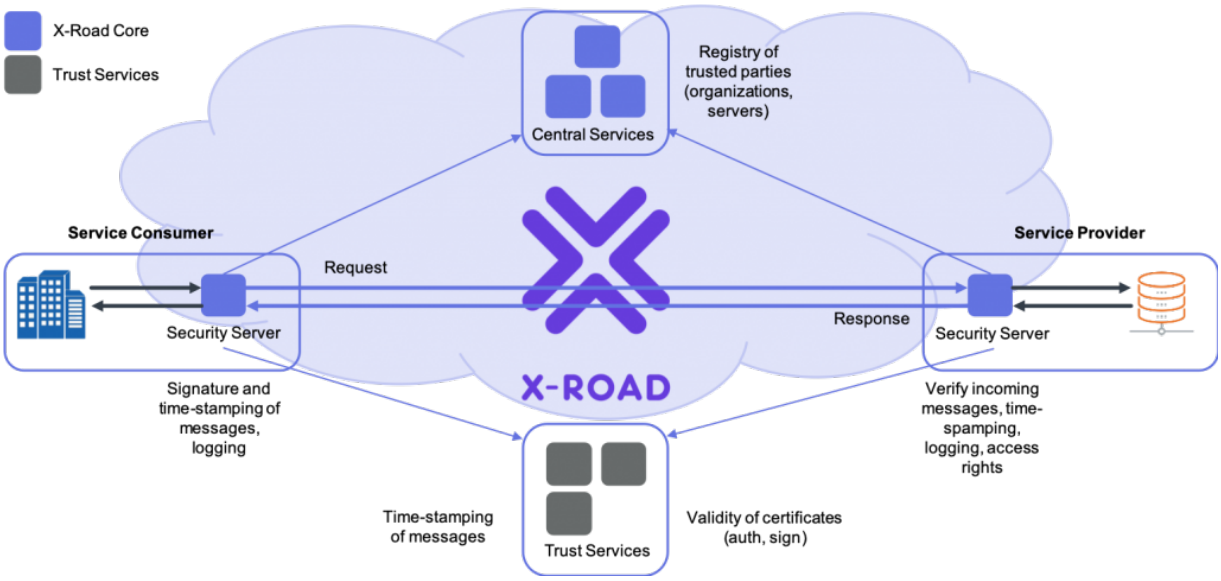

Figure 2.7: XROAD Core Architecture (Petteri, 2020).

Chapter 3: LITERATURE REVIEW

3.1 Overview

The field of e-health has evolved significantly in the modern era but faces many challenges. According to (Gordon & Catalini, 2018), there is a lack of interoperability between different health care institutions worldwide.

Today, although achieving interoperability has become an exceedingly complex task, and there are many obstacles and challenges, it has the potential to provide many benefits for all healthcare users and is valued not only in the academic fields but also by policymakers and other healthcare personnel and decision makers (Majeed, 2010).

This study will be conducted to assess the health organizations' infrastructure in Palestine to achieve interoperability, the requirements for deploying it, and planning for a secure framework between the different Palestinian health care systems, and prove the possibility of a sharable electronic health record for every patient.

Key ideas, theories, concepts, and findings in the current literature

The World Health Organization defined the health information system as *"The health information system provides the underpinnings for decision-making and has four key functions: data generation, compilation, analysis and synthesis, and communication and use. The health information system 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"* (World Health Organization [WHO], 2008).

Security is defined as *"Authorization and authentication, user access, and audit of patient record access and modification, uniform identification of patients, security of data during transmission and at rest".* (Berryman, Yost, Dunn, & Edwards, 2013).

CDA is a document markup standard that specifies the structure and semantics of clinical documents. A CDA document is a defined and complete information object that can include text, images, sounds, and other multimedia content. The document can be sent inside an HL7 message and can exist independently, outside a transferring message (Robert, Dolin, Liora, Calvin, & Paul, 2001).

Achieving an innovative framework that enables electronic health records to be exchanged in a faster, secure, and more efficient manner, and secure transactions between business-to-business and business-to-consumer, so interoperability is needed at the time that data should be shared combined between health care systems (Olaronke et al., 2013).

According to the author, a secure and privacy-preserving interoperability framework in Palestine can be defined as the sufficient amount of tools, software, and infrastructure needed to protect medical records from unauthorized access, hacking, misuse, or attacks and will make it possible to electronically exchange such data among healthcare institutions. This framework requires periodic evaluation of security techniques and policies as well as using up-to-date security techniques on-demand basis. This can be achieved by the deployment of global security and privacy standards, updating systems and software, and auditing logs to record all requests on the system. We believe that the Ministry of Telecommunications and Information Technology and the Ministry of Health can manage this task efficiently.

3.2 Literature Review

The use of literature review at the beginning of the research aims to build a foundation and share the results of the various studies, it helps to fill the existing gaps and form research questions and helps in future studies, and different sources of data are used as in the published documents, articles, books, and websites. The literature review helped the authors obtain information about e-health care services regarding e-health patients and interoperability, in this section we will focus on the benefits of interoperability between health care institutions in Palestine as well as other similar countries.

3.3 Local Studies

- The Palestinian researchers Dr. Muhannad Al-Jabari and Dr. Carol Al-Jabari (2020) conducted research entitled (Towards a New Paradigm of Federated Electronic Health Records in Palestine), the research aims to propose a Federate health information system based on a clinical document architecture (CDA) compatible with the Palestinian context, where this architecture also provides a standard electronic health record through a blockchain architecture to enhance interoperability with scalability, fault tolerance, privacy, and security. The new architecture and technologies will enhance services by allowing healthcare players, patients, and others the opportunity to improve access and control of health services (El Jabari et al., 2020).

  The researcher believes that the adoption of blockchain technology in the field of health will face many challenges, the most important of which is data storage and management, in terms of data storage outside the scope of health institutions and in different places around the world, in addition to the high cost and the need for a relatively huge infrastructure, in addition to the fact that the infrastructure of health

institutions It cannot support these technologies at present, in addition to the fact that Palestine is technically not equipped with such technologies.

- In another research conducted by researcher Arwa Al-Najjar (2021), entitled (An Electronic Health Records Interoperability Model among Hebron Hospitals in Palestine). The study sample consisted of 196 physicians, a stratified random sample from a study population consisting of 402 physicians working in Hebron hospitals. The questionnaires were used as a tool for the study. The researcher aimed to investigate the current status of electronic health records exchange in Palestine. Additionally, the author studied the readiness of different hospitals in Palestine for the possibility of implementing electronic health records interoperability and then developing an appropriate model for interoperability between health care institutions. The quantitative research was based on a questionnaire collected by the researcher from healthcare professionals showed that there is a lack of infrastructure for data exchange and that the high cost is an obstacle to the achievement of interoperability in their institutions. In addition, the analysis showed that doctors in all specialties are optimistic about prospects for the electronic exchange of different health records because they see that as a benefit to society as a whole. The results confirmed that there is no interoperability between the different healthcare institutions in the city of Hebron.

  Arwa Al-Najjar proposed a framework called islEHR that was based on artificial intelligence and HL7 FHIR interoperability standards to enable data sharing in a standard format that humans and computers can use among Hebron healthcare institutions, The system evaluation results indicated that islEHR can be used with a

high level of efficiency and accuracy, which means islEHR is a viable approach to electronic health records sharing in Hebron and can be generalized to share data between hospitals in Palestine. (Najjar, 2021).

The researcher sees the results of Arwa Al-Najjar's research as great results that can be built upon, but the difference in the current research is the study community and the target sample, as this research was more diverse and comprehensive. Also, Arwa Al-Najjar's research did not address the privacy and security of health information, in addition to suggesting a model for interoperability between the internal organization systems that are not implemented in Palestine. In our research, the researcher suggested a framework that is applied in the fields of e-government in Palestine, and it can be easily generalized to the health field.

3.4 Regional Studies

- Meshal ALSADAN (2015), presented a paper titled (Health Information Technology (HIT) in Arab Countries: A Systematic Review Study on HIT Progress), the search discussed 655 studies. The author stated that Health Information Technology (HIT) in the Arab region, especially in developing countries, is often lagging in the current implementation of health information technology systems in developed countries. The research aimed to identify and study the current situation of HIT within the Arab countries and discussed ways to use and secure HIT systems, find obstacles and suggest possible solutions to implement HIT. The results of the study showed that most Arab countries are left behind in HIT due to the lack of allocated financial resources and professional inefficiency, as public hospitals funded by governments lack the professional use of information technology, while private hospitals do not

have sufficient funds to implement HIT. E-Health is the basis for the development of the healthcare sector in many forms such as telemedicine and electronic health records. Arab countries need to develop strategic plans to overcome financial and cultural barriers to be competitive in the field of HIT, and also encourage and support research centers to promote scientific research in this field (Alsadan et al., 2015).

- In the Kingdom of Saudi Arabia, Fahad Alanezi presented a paper titled (Factors affecting the adoption of e-health system in the Kingdom of Saudi Arabia, 2021). In this research, a questionnaire was designed and distributed randomly through social media and the web among KSA citizens, and the survey-based quantitative analysis method was used, the sample consisted of 130 Saudi citizens. The paper discussed the status of e-health and its systems in Saudi Arabia. The results of the research indicated that the relationship between doctors and patients prevents the application of this system, to fears of a possible breach of data privacy, the lack of governmental and regulatory regulations, in additional to demographic factors such as age, gender, residence, income, education, and culture create obstacles to the adoption of the e-health system. The study suggested that professionals should contribute to modifying the e-health system, adding more government regulatory agencies to increase adoption, and modifying existing strategies to reach a successful e-health framework in the Kingdom of Saudi Arabia (Fahad, 2021).
- Mahnuma Rahman Rinty presented a paper titled (A prospective interoperable distributed e-Health system with loose coupling in improving healthcare services for developing countries, 2021). The research is an experimental study for designing and developing an e-health model to improve health care services, including system

architecture, data storage, electronic health record server, and implementation phase. The paper discussed interoperability through distributed systems in the healthcare architecture, the research aimed to develop a prospective e-health system for developing countries to improve the effectiveness of healthcare services, and this research presented an improved framework for e-health using distributed storage in the processing of heterogeneous data using Health Level 7 (HL7) and Message Passing Interface (MPI) to store regular copies of heterogeneous health data. Based on the experimental results, the distributed database was made accessible from a remote server using coupled technologies, it also provided e-health data recovery features and handled a large database through a distributed environment. According to the study, the developed system can provide a low-cost service to the community of developing countries (Mahnuma, Uzzal, Mijanur, 2022).

3.5 International Studies

- Goce Gavrilov conducted a study titled (Healthcare data warehouse system supporting cross-border interoperability, 2021), which aimed to propose a new design for a healthcare data warehouse based on the usual extraction, transformation, and loading process structure. The free movement of European citizens across EU member states has an important level of complexity for the strategic efforts of interoperability between different care organizations in EU countries, where cross-border healthcare depends on the ability to set up common practices regarding patient data across countries. It must comply with data flows with legal, security, political, and interoperability requirements. This is done through the use of the Health Level 7 Standard and the Open National Contact Point Framework to provide a modular,

scalable, applicable, and interoperable architecture (Gavrilov, Vlahu-Gjorgievska, & Trajkovik, 2020).

- In another study conducted by Shaun Mehta (Future of blockchain in healthcare: the potential to improve the accessibility, security, and interoperability of electronic health records, 2020), the study states that inaccessibility of medical records for both patients and doctors has long been recognized as an obstacle to health care transparency and efficacy, while electronic health record systems help address this problem to some extent, many heterogeneous systems showed variable success in this regard. According to the study, many EHRs in the current state are struggling with the core benefits of digital information technology as simple user experience, and sharing capabilities. This study suggested the blockchain framework be used as one of the possible solutions that give many benefits that can be exploited for interoperability between different healthcare institutions. The study considered that the blockchain is a nascent and new technology, and there are major technical, regulatory, and institutional barriers that limit its full potential in medicine (Mehta, Grant, & Ackery, 2020).
- Faheem Reegu presented a paper titled (Interoperability Challenges in Healthcare Blockchain System-A Systematic Review), The study aimed to identify the challenges of interoperability and issues of blockchain EHR frameworks, by national and international standards for electronic records, to identify interoperability standards within the EHR framework in terms of medical data distribution, sharing and data reliance. The paper proposed an implementation of electronic health records and provided a solution that will help with data management, patient information

security, blockchain benefits, and electronic records interoperability (Reegu, Daud, & Alam, 2021).

3.6 Comments on Previous Studies

The previous studies reviewed on this topic focused on e-health, the importance of e-health systems and their automation, and the importance of interoperability between distributed health institutions, at the level of patients, doctors, and health workers. These studies included various health institutions in Palestine and Arab and foreign countries in general and were used to enrich the theoretical and conceptual framework in developing the study tool, as well as to explain the results of the current study through analysis and comparison with the results of these studies.

Previous studies concentrated on e-Health, infrastructure for interoperability, the interoperability of distributed systems, and the use of different frameworks of interoperability such as Blockchain. The studies also investigated the cost, benefits, and challenges in implementing interoperability, as well as the use of international standards commonly used in interoperability. Since most Arabian countries are developing countries, some studies concentrated on making comparisons between Arab countries and other developed countries, the challenges and obstacles to implementing interoperability in Arabian countries were introduced based on these comparisons.

The main objective is to improve the exchange of medical data and thus the use of many frameworks and international standards for implementing interoperability in Palestine; therefore, a variety of methods were used to collect information including questionnaires, interviews, the study of previous literature, and description and comparison methods. This

study was consistent with most previous studies on the importance of interoperability and its great benefits in developing health systems in developing countries.

3.7 The Knowledge Gaps

Despite the benefit of data interoperability in healthcare organizations, now it is a goal that has not been achieved to a large extent in many developing countries, and the reason for this is that health information systems used in healthcare institutions have been developed independently using various tools, methods, processes, and procedures. This led to many heterogeneous and distributed ownership frameworks to represent and record patients' information (Majeed, 2010). Therefore, independence is the reason for the difficulty of interoperability between information systems and can be overcome by implementing and adopting appropriate standards (Barbarito et al., 2012).

There are many standards to address the interoperability of clinical information between healthcare centers, however, the absence of uniform standards for clinical health information that can be shared between different healthcare centers led to creating a lot of problems in different aspects. Many developed countries are working and focusing on developing and using healthcare information to provide various services in the health field (Majeed, 2010), they look at how the interoperability framework can facilitate transmission through many mechanisms, including digital access rules, data integrity, patient identity, and data stability. From another point of view, these countries studied the barriers against patient-driven interoperability supported by the exchange of health information, specifically the volume of clinical data transactions, safety, privacy, patient participation, and incentives. They concluded by noting that the interoperability of patient care is an exciting trend in healthcare,

given these challenges, we must see if the framework can facilitate the transmission and sharing of data from institution-centric to patient-centric data (Gordon & Catalini, 2018).

In Palestine, there are many efforts to establish a sound system for electronic health records in public and private health care organizations, but there are still many obstacles and challenges, to summarize the main contribution in this files in Palestine, we list the following: A theoretical framework of Federated Electronic Health Records in Palestine was proposed by (El Jabari et al., 2020), where the authors suggested the use of blockchain to create a unified electronic health record based on CDA. (Shawahna, 2019) talked about the importance of using electronic health records with clinical decision support systems (CDSS), which enhance the compliance and secure use of electronic records. Another interesting contribution was carried out by Arwa Najjar (Najjar, 2021), who proposed an interoperable system among two different hospitals in Hebron District in Palestine.

3.8 The Research Will Add and Contribute to the Existing Body of Knowledge

The research papers evaluate the concepts of interoperability in the health care context and its benefits and challenges, they also suggest different models to achieve interoperability, they also addressed the adoption of education strategy, standardized healthcare terminology, design of usable interfaces For ICT tools, security and privacy issues, as well as linking different systems to the health network. The previously addressed issues are ways to achieve full interoperability of electronic health information between different health care systems. Also, the research studies aimed to determine the technical interoperability of health information systems in hospitals and health care organizations and to suggest models and guidelines for establishing and developing interoperability between these centers (Majeed, 2010).

After looking at the literature on interoperability and many e-health standards, types of interoperability, and most importantly the possibility of interoperability within healthcare institutions, we will look at the possibility of reducing the interoperability gap between healthcare centers in Palestine using information and communication technology tools (Majeed, 2010).

Standard is “a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context” (Kotzé, Adebesin, Foster, & Greunen, 2013), So the main objective of these standards is the exchange of Electronic Health Record (EHR) by defining some structures and markup. These standards are focusing the structure of the content, the functionality of the requested retrieval of the record, the complementarities of different standards, and how they influence the market relevance (Majeed, 2010), HL7 and CDA are common examples.

In this research, we will focus on the current challenges and benefits of interoperability in Palestine, and we will work on analyzing some systems in health care centers to verify the presence or absence of interoperability, and how the decision-makers in these organizations or strategy makers can achieve interoperability. The study would also assist patients and physicians in accessing clinical information and would record a high level of satisfaction with the health service provided for patients and healthcare users through interoperability.

Upon our reviewing of some research done in the field of interoperability frameworks in Palestine, we found that a great effort was done by Arwa Al-Najjar with her prototype framework called islEHR which was based on artificial intelligence approaches and HL7 FHIR interoperability standard to enable data sharing in a standard format that humans and

computers can use. However, the prototype was limited to two hospitals in Hebron city and did not deeply address the security and privacy issues related to data exchange. Besides, the prototype did not introduce centralized control for data exchange among these institutions (Najjar, 2021).

For these reasons, our research will aim to design a secure framework for interoperability among Palestinian institutions that has the following properties:

- The study will include hospitals from different cities in Palestine which will enable us to better analyze the status of interoperability in Palestine.
- We will provide a centrally controlled interoperability framework where a trusted third party (MTIT) will be able to control the exchange of data among different healthcare institutions.
- Due to the sensitivity of data and its effect on patients' privacy, our framework will focus on securing the exchange of data.
- The framework proposed by the researcher is available in Palestine and owned by the Palestinian Ministry of Telecommunications.
- Sufficient expertise and technical staff are available for implementation by the Ministry of Telecommunications and Information Technology.

Chapter 4: RESEARCH METHODOLOGY

4.1 Introduction

This chapter presents the research methodology used, through which the applied aspect of the study is achieved, and the data necessary to conduct the statistical analysis to achieve the results that are interpreted and thus achieve the objectives of the study. The theoretical framework was discussed in the second chapter and the literature review in the third, the research methodology is introduced in this chapter and contains the designed interviews conducted with the IT managers of health care centers. The discussion of the questionnaire will be done in the following chapters.

4.2 Overview

Our study is conducted using a mixed research methodology that includes both quantitative and qualitative research methods. Initially, the researcher conducts literature reviews to obtain an understanding of E-Health and E-Health services (medical information about the patient's electronic health record (EHR), interoperability and the criteria used, the challenges and benefits related to interoperability between different healthcare institutions, and the importance of interoperability to patient medical information between health care centers.) The literature review helps in adopting the method of conducting the interviews, analyzing the results of the collected data, and distributing the questionnaire to obtain data and verify the validity of the study.

In this research, interview methods and questionnaires will be used to collect data. Interviews are conducted to ask detailed questions and follow-up with e-health strategy makers, health services planners, and health care service providers. The interview is a qualitative research method that includes a series of questions asked by respondents to collect data. They can be

held remotely via mail or phone and by going in person to the respondents. After conducting the interviews, the researcher analyzes this collected data, then the questionnaire is designed and distributed based on the results through interviews and the validation of the study. The questionnaire is a quantitative research method designed to collect quantitative data. Includes open or closed questions, Figure 4.1 shows an overview of our research methodology

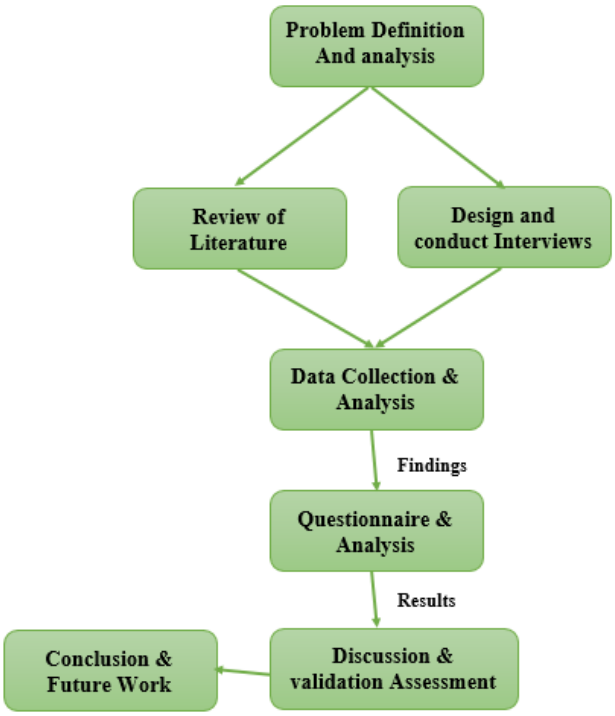

Figure 4.1: Overview of Research Methodology (Majeed, 2010).

4.3 Interviews

The researcher conducted structured interviews to provide theoretical support for the study, the researcher collected sufficient data to conduct interviews with employees responsible for health electronic systems in the various institutions covered by the study.

There are several objectives of the interviews, first to conduct an in-depth investigation to determine the benefits and challenges of achieving interoperability, second is to provide more

facts and support for the qualitative materials collected in this research, as well as to use the appropriate model of information that can be useful during the existence of interoperability between health care institutions (private and public) in Palestine. Hence, the researcher will create several open questions that can help the interviewees share their thoughts comfortably about the scope of the research, the interviewee must know well all the general trends of interoperability, the information necessary for interchange between healthcare centers, and current challenges for achieving interoperability.

4.4 Questionnaire

The researcher designed the questionnaire and then it was evaluated by many researchers working in the health informatics research field, then it was distributed to various health workers. The purpose of the questionnaire was to obtain qualitative and quantitative data to support the results we seek. Questions were designed in a way that enables health information technology officials and healthcare providers in Palestine to provide their opinions about the possibility of interoperability, the method, and framework proposed by the researcher to achieve interoperability between healthcare institutions in Palestine, and how to benefit from interoperability by health care providers in Palestine.

4.5 Sources of Information

The researcher relied upon two main sources of information:

Primary Sources: The researcher used well-prepared questionnaires and structured interviews dedicated to the subject of the study as the best method for collecting primary data to reflect the analytical aspect of the study.

Secondary sources: To address the theoretical aspects, the researcher used related books, magazines, articles, websites, studies, reports, and other published research that represent secondary data sources.

4.6 Study Population

The target study area is the hospitals and healthcare institutions accredited by the Ministry of Health and the general administration of the hospitals. The public and private sectors will be included to achieve this study.

The researcher identified the study population in five health care hospitals in Palestine, where the hospitals were distributed, firstly Hebron hospitals, which was represented by Al-Ahli Hospital, Al-Meezan hospital, and the governmental hospital of Hebron (Alia), and secondly by the hospitals in Ramallah and Al-Bireh, which were represented by the Palestine medical complex (PMC) and the Istishari Arab Hospital. The study included medical workers who deal directly with medical records and various health information systems. The study community included three hospitals from the private sector (Al-Ahli Hospital, Al-Meezan hospital, and the Istishari Arab hospital), and two hospitals from the public sector (the Palestine medical complex (PMC) and the governmental hospital of Hebron (Alia). Table 4.1 presents the study population, according to the human resources department (HR) of the mentioned institutions.

The size of the study population will be from the hospital's human resources department, represented by directors, doctors, nurses, medical directors, medical laboratory doctors, medical imaging, health information system administrators, pharmacists, anesthesiologists, and other experts, with a background of HIS, in Hebron and Ramallah Hospitals, including the public health sectors (the Palestine medical complex (PMC) and the governmental

hospital of Hebron (Alia), and the private health sectors Al-Ahli Hospital, Al-Meezan hospital, and the Istishari Arab hospital).

Table 4.1: study population

Healthcare center	**Number of health workers**
Al-Ahli Hospital	640
Al-Meezan hospital	110
The governmental hospital of Hebron (Alia)	550
Palestine medical complex (PMC)	670
Istishari Arab hospital	380
Total Population	**2350**

Table 4.2 shows the number of employees covered by the research in private hospitals relative to employees in public hospitals. The percentage of employees in the private sector is higher than in the public sector because the study includes three hospitals from the private sector in contrast with two hospitals from the public sector. The difference will not affect the study since all public sector hospitals use the same healthcare information system and the same environment, on the contrary, private sector hospitals use different environments with different healthcare information systems.

Table 4.2: population study quotas

Subgroup	Subgroup Weightage	Quota Size	Population
Private healthcare centers	60 %	199	1410
Public health care centers	40 %	132	940

4.7 The Study Sample

The target of the sample will be the public and private health sector personnel, non-probability sampling through a stratified sampling method is used, the sampling method involves dividing the population into subgroups called strata and, in this research, the two subgroups will include (Health workers in the private sector and Health workers in the public sector), employees will then be interviewed, and the questionnaires will also be distributed and analyzed.

The size of the study population is 2350 employees - as shown in Table 4.1 -working in the health field in five hospitals, including two public hospitals representing 1220 employees and three private hospitals representing 1130 employees. A sample of the study was selected with 6% of the population and represented by 41.4% from the public sector and 58.6% from the private sector. This difference was based on the difference in the population size of the two subgroups used, 40% public sector hospitals versus 60% private sector hospitals.

The study sample consisted of 331 questionnaires, with a margin of error of 5%, and a confidence level of 95%. The researcher distributed 331 questionnaires to employees in the

study hospitals, and the number of response questionnaires was 140 questionnaires out of the total number, due to the lack of cooperation of employees in filling out the questionnaire.

The study sample response of 140 questionnaires of a sample proportion of 6% of the study population with a confidence level of 95% has a margin error of 8%. According to the KP Suresh and S Chandrashekara study entitled "Sample size estimation and power analysis for clinical research studies", the acceptable margin of error in clinical survey research is from 5-10%, meaning that the margin of error in this research is acceptable (Suresh & Chandrashekara, 2012).

4.8 Sampling Techniques

In this study, it was impossible to include all physicians in the community or to randomly select individuals to participate. Therefore, non-probability sampling was adopted as a method for this study. An effective method for selecting a sample that represents the population is quota sampling because the number of private hospitals covered in the study differs from public hospitals. Accordingly, the researcher divided the community into two sub-groups, the first group representing private hospitals and the second group representing public hospitals. Then, a quota was assigned to each subgroup based on the proportion of the group's representation of the community. The proportion in which subgroups are present in a population is calculated using the following formula:

Subgroup Weightage

$$= \frac{Total\ Number\ Of\ Health\ care\ centers\ In\ The\ Group}{Total\ Number\ Of\ Health\ care\ centers\ In\ The\ Population} \times 100\%$$

By finding the weightage of each subgroup in the population, these percentages are then used to calculate the size of the quotas using the following formula:

$$Quota\ Size = Subgroup\ Weightage \times Sample\ Siz$$

Table 4.3, shows the number of questionnaire responses for private and public hospitals, which represents (n = 82, 58.6) in the private sector and (n = 58, 41.4) in the public sector.

Table 4.3: Sample study quotas

Subgroup	Subgroup Weightage	Quota Size
Private healthcare centers	58.6 %	82
Public health care centers	41.4%	58

4.9 Study Period

The study was carried out between September 2021 and Jul 2022.

4.10 Study Tools

To assess interoperability among health care institutions in Palestine, the researcher developed the questionnaire and structured interview as follows:

4.11 Interviews with Directors of Computer and Engineering Departments

The Computer and Engineering Department in the various healthcare institutions in Palestine is responsible for the various health information systems from managing, developing, installing, updating, following up, daily technical support, data storage and retrieval, and backup copies. These issues are the basis of interoperability between the various healthcare institutions. The interview was developed to cover the internal procedures and the infrastructure available at the various healthcare institutions to support interoperability between healthcare institutions in Palestine. The interview questions were designed to include most of the international assessment frameworks for interoperability, such as EMRAM, where the questions addressed the assessment of existing infrastructure and

systems (their capabilities and interoperability), challenges and benefits, standards used and readiness, privacy and security, decentralized environment, the role of information technology and other things that have been measured. For further details about the contents of the conducted interviews, please refer to appendix (C);

The interview included 26 questions on the subject of the study. The interview questions included the importance of interoperability from the point of view of the managers of the computer and engineering department, the currently available systems and their characteristics, the challenges that interoperability may face, and to what extent these institutions are ready for interoperability, and is it possible to achieve interoperability soon in Palestine or not? The interview also included questions about standards for interoperability and their importance, patient privacy and methods of protecting medical information, the decentralization framework for interoperability, the databases used, and to what extent is the Ministry of Telecommunications and Information Technology capable to achieve interoperability through the data exchange and protection systems it uses? Questions about if Physicians can have access to medical information at the right time and place? Or do they support interoperability proposals and their feasibility and operation? Other questions about annual risk assessments and follow-up of medical records were also presented.

4.12 Questionnaire for Health Workers

while health field workers, including doctors, nurses, laboratory technicians, medical imaging, and others, are the real beneficiaries of medical data and are the producers and consumers of it, the questionnaire was developed to assess interoperability between health care institutions in Palestine and its applicability and importance from their point of view, for better understanding the questionnaire, please refer to Appendix (D).

The questionnaire included 6 main parts. The first part consists of the consent form, which contains a brief explanation of the topic of the research, in addition to the participants' appreciation for allocating part of their precious time and emphasizing the need for credibility in answering the questions.

The second part consists of demographic information to determine the characteristics of the sample in terms of age, gender, job level, specialization, number of years of experience, workplace, number of years of using electronic health information systems, and the department in which they work.

The third part aims to determine how data is exchanged in the organizations in which they work in terms of tools used, time to obtain patient information from another organization, interoperability usefulness for patients and health workers, and whether the ICT platform can play the primary role in interoperability, the importance of standards of data sharing, whether the Palestinian government is responsible for achieving interoperability in terms of laws, regulations, and policies, and whether electronic systems can be an alternative to paper-based systems.

The fourth part aims to measure and identify interoperability challenges between healthcare organizations in terms of communication, privacy, security, infrastructure, policies, trust, and other measurement and evaluation tools.

The fifth part aims to identify the benefits and advantages of interoperability between private and public health care institutions at the level of patients, health care providers, and health workers.

The sixth part aims in the first stage to specify the patient's information that must be exchanged electronically, such as the electronic health record, vital signs, allergy list, the

patient’s family history, treatment, medical pictures, devices used, and entry and exit instructions, laboratory test results, medical diagnosis, and other information that could be useful if exchanged. The second stage aims to identify the important technical elements and characteristics that lead to the success of interoperability, such as the presence of a trusted third party to manage interoperability such as the Palestinian Ministry of Communications and Information Technology, in terms of devices, equipment, tools and programs that help exchange data quickly and reliably and with high safety among health institutions in Palestine.

4.13 Validity of the Questionnaire

The validity of the questionnaire is a measure of the quality of the questionnaire, and if it does reflect the objectives that we aim to measure through it. The researcher verified the validity of the questionnaire through the arbitrator’s validity of "virtual honesty". The researcher designed the questionnaire in its initial form and then presented it to the supervisor to ensure its validity and then it was presented to a group of specialized arbitrators consisting of 6 specialists in the field of medical records and data security to show their suggestions, and their names are listed in Appendix (A), after which the amendments were discussed with the supervisor and the questionnaire was modified to appear in its final form.

4.14 Questionnaire Reliability

The reliability of the questionnaire aims to give the questionnaire the same result if the questionnaire is redistributed more than once in the same circumstance, or other words, it means the stability of the questionnaire, where the results of the questionnaire will not change significantly if it is distributed several times during a certain period.

The questionnaire was distributed to 10 people in the health field, and all the questions were discussed with them the necessary modifications were made to the questions based on the discussions, and then the Cronbach coefficient was measured to discover the reliability of each question. The questionnaire was directed again after the required modifications and approved by the study sample.

Table 4.4 shows Cronbach Alpha results, it indicates that the consistency values of the study tool among health workers in private and public study hospitals amounted to 89.7%, and therefore the tool (the questionnaire) had a high degree of consistency. It can be adopted to achieve the objectives of the study.

Table 4.4: Cronbach's Alpha results.

Scale	Cronbach's Alpha	Number of Questions	Cronbach's Alpha Based on Standardized Items
Data Exchange Condition	0.771	8	0.816
Interoperability Challenges	0.887	10	0.890
Interoperability Benefits	0.948	15	0.949
Interoperability Data Requirements	0.953	13	0.954
Interoperability Technical Requirements	0.924	12	0.936
Total Degree for The Instrument	0.897	58	0.909

4.15 Study Phases

- Determining the subject of the study, which is "Towards Secure Interoperability EHR among Healthcare Organizations in Palestine".

- ❖ After verifying the validity of the study tool, the researcher printed and distributed (140) questionnaires to health workers in the private and public hospitals on which the study is based.
- ❖ Hospital workers filled out the questionnaire with what was required, then the researcher collected the form after verifying the required data.
- ❖ The researcher filled the data into the SPSS program to analyze and extract the results.

4.16 Statistical Methods

After collecting the questionnaire forms and study data and verifying their validity for analysis, the researcher reviewed them in the formulation to be entered into the computer for statistical processing.

A five-point Likert scale was used, which is a method of measuring behavior used in the questionnaire, especially in the field of statistics. The scale is based on the answers that indicate the degree of agreement or difference in safe interoperability between private and public health care institutions in Palestine, based on arithmetic averages as in Table 4.5.

The data collected from the questionnaires were entered into the SPSS program by assigning certain numbers to them, that is, by converting verbal answers into numerical values, indicating the response as strongly agree (5), agree (4), neutral (3), disagree (2) strongly disagree (1), Table (4.5) Shows the 5-point Likert scale. So, the higher the degree, the greater the importance of interoperability between private and public health care institutions in Palestine in a safe way, either in the answer yes (1), no (2) and I don't know (3), Table (4.6) shows Table Yes\No Scale.

The answers I don't know were represented as missing values because they do not represent a real value that can be adopted and the Likert scale does not support them during the analysis [4].

Table 4.5: The 5-point Likert scale

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Table 4.6: Yes\No Scale

1	2	3
Yes	No	I don't know

The researcher determines the weighted average of each point of the 5-point Likert scale. By calculating the range by subtracting the value of the first scale from the last scale ($5 - 1 = 4$). Then, the result is divided by five as it is the highest value on the scale ($4 \div 5 = 0.8$). Afterward, the minimum value of the scale which is 1 was added to identify the weighted average of the first scale. The weighted average for all scales is shown in Table (4.7)

[4] https://www.spss-tutorials.com/spss-missing-values/

Scale	Weighted Average
Strongly Disagree	1 – 1.80
Disagree	1.81 – 2.60
Neutral	2.61 – 3.40
Agree	3.41 – 4.20
Strongly Agree	4.21 – 5

A descriptive analysis was applied to determine the characteristics of the participants, the frequencies, and percentages to describe the demographic variables and to reveal the people's responses to the statements of all cases, as well as to determine the degree and agreement of each response to the study variable. Moreover, the standard deviation was calculated to determine the dispersion for each of the study variables along with the main field, and the closer it is to zero, the more focused and less scattered response. The data were entered and tested with SPSS version 21.

4.17 Study Variables and Conceptual Framework

- **Independent variables:** EHR, EMR, data entry, patient care, decision support, knowledge, inference, repositories, aggregations, data security, and healthcare organizations.

  Dependent variable: Towards Secure Interoperability EHR among Healthcare Organizations in Palestine.

4.18 Ethical Consideration

The researcher obtained ethical approval from the Deanship of Scientific Research at the Arab American University, as well as from the Ministry of Health, and the Human Resources Department of the Istishari Arab Hospital, Al-Ahli Hospital, and Al-Meezan Hospital. Moreover, the researcher invited workers in health institutions to participate in the research project that was conducted in The Palestinian Medical Complex (PMC), Istishari Arab Hospital, Al-Ahli Hospital, Al-Meezan Hospital, and the governmental hospital of Hebron (Alia), the researcher explained to them that their participation is voluntary, and it is up to them to decide whether they will participate in this study, but before participating they need to understand what the research involved, and they agreed and are assured that their participation will not be disclosed.

4.19 Obstacles and Challenges in Collecting Data

The main obstacles faced during the collection of data included:

- The necessary approvals from all institutions,
- Transportation and long distances.
- The lack of sufficient time for the participants to deal with the researcher.
- The reservation of interviews by some participants.
- The failure to disclose all the data required by the participants.

Chapter 5: RESULTS

5.1 Overview

This chapter presents the results of the survey including the characteristics of the respondents and the survey elements with the values of the basic statistical terms "means, percentages, ranks, degrees and standard deviations", which helps in answering the study questions. The survey may have evaluated the possibility of interoperability between health care institutions in Palestine, as well as evaluated the infrastructure of the health institutions covered by the research through interviews conducted with officials of the computer departments in these institutions.

The results of the interviews, and the results of the questionnaires, will be presented below:

5.2 Analysis of Interviews

The researcher translated the data of the recorded interviews into text. The researcher conducted interviews and then collected the data to analyze the information extracted from the recordings. The interviews were scheduled to be conducted with decision-makers and managers of the computer department in health institutions. All interviews with decision-makers in the health selected institutions were rejected, but interviews with officials of the computer departments in these institutions were conducted, hence, the researcher obtained information related to the benefits of interoperability, challenges, obstacles, standards, and electronic infrastructure in these institutions and the possibility of interoperability among them, in addition to the policies, laws, and regulations, the need to legitimize interoperability, the possibility of governmental support for interoperability, and the approval of the

Palestinian Ministry of MTIT through its interoperability system to achieve interoperability in Palestine.

These interviews helped in analyzing the problem domain and how to achieve interoperability among the private and public health care centers.

Tables 5.1 to 5.26 present the answers to all interview questions by IT managers in health centers, according to the objectives mentioned below:

5.3 Interoperability among Public and Private Healthcare Centers.

Table 5.1: Do you have any idea about interoperability with other healthcare organizations? What is the importance of that in your opinion?

Hospitals IT Managers	The answer
Al-Ahli Hospital	The idea of interoperability is available for them and is ultimately in the interest of the patient
Al-Meezan hospital	the idea is present and it is important to the patient and the hospital
The governmental hospital of Hebron (Alia)	We have an idea, which facilitates obtaining information by the patient and the physician anywhere (medical passport) so that the patient can access his medical information in the various medical centers
Palestine medical complex (PMC)	The idea exists and is the focus of the General Department of Computer and Information Technology in the Palestinian

	Ministry of Health to achieve the comprehensiveness of the health situation, but there has been no progress yet.

Table 5.2: Is the electronic health information system in the Palestinian Ministry of Health similar to the electronic health information system in private hospitals? Explain that

Hospitals IT Managers	The answer
Al-Ahli Hospital	The similarity between health information systems in different health care institutions is high because they contain the same information as the electronic health record, also the services provided are similar, but the difference is in the software used, the development in technology solves this problem simply by using APIs.
Al-Meezan hospital	The systems are similar in the mechanism of action in all hospitals in terms of electronic health records and information related to the patient, but the difference is in the software used.
The governmental hospital of Hebron (Alia)	There is a similarity in some points, but the difference is in the system itself, except the system at Al-Makassed Hospital, which is almost like the system of the Ministry of Health
Palestine medical complex (PMC)	The electronic health information system in Al-Makassed Hospital is similar to the Ministry of Health system. Also, the apex system used in Istishari Arab Hospital and H Clinic

	Hospital is similar to the Avicenna system used by the Palestinian Ministry of Health

Table 5.3: What are the health information systems that you work with and what are their characteristics, if any?

Hospitals IT Managers	The answer
Al-Ahli Hospital	Al-Ahli Hospital uses the CARE system, and it is used in managing the electronic health record, moreover, it supports financial and administrative sectors .it has been used since 2000
Al-Meezan hospital	The electronic system is built by a developer team affiliated with the hospital. the system works on managing the electronic health record completely
The governmental hospital of Hebron (Alia)	The system used by the Palestinian Ministry of Health is the Avicenna system and is used to manage patients' medical records and various Administrative and financial records. As well as the PACS system for managing and archiving medical images.
Palestine medical complex (PMC)	The system used is the Avicenna system as mentioned above, in addition to the PACS system for managing and archiving medical images, besides the medical transfers and the Corona tests management systems, moreover, there is integration within the Palestinian Ministry of Health among these systems.

Table 5.4: Do you agree that there should be interoperability between health care organizations in government health centers and private health care centers?

Hospitals IT Managers	The answer
Al-Ahli Hospital	Yes, there should be interoperability among health care centers, because it would benefit the patient.
Al-Meezan hospital	Yes, to provide patients' medical records in all healthcare centers, reduce costs, and prevent medical test duplication, hence decreasing the time for diagnosis.
The governmental hospital of Hebron (Alia)	Yes, to facilitate diagnosis, treatment, and patient follow-up in all medical centers in addition to reducing medical errors and costs.
Palestine medical complex (PMC)-	Yes, to save resources such as storage, saving money, and reducing radiation risks, moreover to exchange experiences among physicians in different healthcare centers, hence raise the quality of health care.

5.4 The challenges for Interoperability

Table 5.5: What are the challenges in adopting interoperability between government health care centers and private health centers?

Hospitals IT Managers	The answer
Al-Ahli Hospital	The most important challenges are secure data exchange, maintaining patient privacy, protecting databases from unauthorized access, maintaining institution's privacy, and preventing medical information transfer without the patient's consent, and this needs policies and laws
Al-Meezan hospital	The expected challenges are obtaining information in the correct way and systems integration.
The governmental hospital of Hebron (Alia)	They need a private and unified Internet (for data exchange) among the different institutions, the approval of the various departments to exchange and implement the system, in addition to the lack of clear policies and laws on how to exchange and store the data.
Palestine medical complex (PMC)	Medical errors, policies, laws, and the judiciary.

Table 5.6: What are the challenges in adopting interoperability between government health care centers and private health institutions?

Hospitals IT Managers	The answer
Al-Ahli Hospital	There is no technical problem with interoperability if there are policies, laws, and regulations that support it. Also, Al-Ahli Hospital has a good Infrastructure for interoperability, and it is possible to interoperate with the electronic health record.
Al-Meezan hospital	The possibility to provide the electronic health record which includes medical history, medical tests, reports, radiographs, and discharge reports. But there is poor infrastructure for interoperability.
The governmental hospital of Hebron (Alia)	The exchange of the electronic health record with all its contents.
Palestine medical complex (PMC)	There is no readiness in terms of the health record because the Avicenna system needs updating. The Palestinian Ministry of Health infrastructure is insufficient and needs to be developed, although the rest of the systems such as the radiology system are ready.

5.5 Vision of Interoperability

Table 5.7: What is your vision for interoperability soon?

Hospitals IT Managers	The answer
Al-Ahli Hospital	From a technical point of view, most institutions are ready, but the legal problem is what hinders interoperability. If it is solved, interoperability can be achieved within a year by the Ministry of Telecommunications and Information Technology.
Al-Meezan hospital	The expected period is from 1-5 years to achieve interoperability in Palestine.
The governmental hospital of Hebron (Alia)	There are many problems, including financial support, policies, and laws
Palestine medical complex (PMC)	The Ministry of Health does not have the permissions necessary to compel private medical institutions to interoperate, but the decision can be taken by the Council of Ministers.

5.6 ICT's role in interoperability

Table 5.8: Can ICT securely solve the interoperability problem with a clarification?

Hospitals IT Managers	The answer
Al-Ahli Hospital	Yes, with imposing all health institutions under the control of the Palestinian government, in addition to providing adequate laws to protect institutions and individuals.
Al-Meezan hospital	Yes, if a security system is available for interoperability.
The governmental hospital of Hebron (Alia)	Yes, if there are laws, regulations, and complete infrastructure,
Palestine medical complex (PMC)	Yes, with the use of the XROAD system, and the data center located in the Palestinian Ministry of Telecommunications and Information Technology.

5.7 About Palestine National Health strategy and national database.

Table 5.9: Is the system you are using connected to a national or non-national database, what are the communication standards, and what is this database, if any?

Hospitals IT Managers	The answer
Al-Ahli Hospital	

Al-Meezan hospital	They answered that there is no clear strategy for interoperability between the various health care institutions in Palestine, and there are no policies and laws to regulate and protect interoperability.
The governmental hospital of Hebron (Alia)	
Palestine medical complex (PMC)	

Table 5.10: Can clinicians have access to a national or regional database of patients to support decision-making (e.g., medications, images, allergies, lab results, etc.?) List these systems if any.

Hospitals IT Managers	The answer
Al-Ahli Hospital	They answered unanimously that there is no national database, but Muhammad Salah al-Din and Ibrahim al-Hasanat added that the database owned by the Palestinian Ministry of Health includes most of the health institutions and centers affiliated with the Palestinian Ministry of Health- about 80% of the medical institutions in Palestine- but private institutions have different databases and different types of them such as SQL
Al-Meezan hospital	
The governmental hospital of Hebron (Alia)	

Palestine medical complex (PMC)	Server, Oracle Database, and others, and physician can access the data according to the permissions granted to them, whether they are from the institution or not.

5.8 EHealth standards for Interoperability

Table 5.11: Do you think standards are important to achieve interoperability between government healthcare centers and private healthcare centers?

Hospitals IT Managers	The answer
Al-Ahli Hospital	All of them focused on the importance of interoperability and the exchange of various health data.
Al-Meezan hospital	
The governmental hospital of Hebron (Alia)	
Mohammad Salah Al-dine-the	

Table 5.12: Do you have any approved standards (ICD, HL7, SNOMED CT, LOINC, DICOM, and ISO)? If so, mention them.

Hospitals IT Managers	The answer

Al-Ahli Hospital	Both of them answered that they did not adopt any standards for interoperability.
Al-Meezan hospital	
The governmental hospital of Hebron (Alia)	Both confirmed the use of the HL7 standard in integration with the various internal systems of the Ministry of Health.
Palestine medical complex (PMC)	

5.9 HL7 standard for interoperability

Table 5.13: How is the HL7 standard used in achieving interoperability?

Hospitals IT Managers	The answer
Al-Ahli Hospital-	The mentioned standard works to standardize data and facilitate the connection between different healthcare institutions
Al-Meezan hospital	The standard clarifies the procedures and steps for interoperability
The governmental hospital of Hebron (Alia)	Both said It is used when integrating different health systems, such as the internal systems in the Ministry of Health.
Palestine medical complex (PMC)	

5.10 Decentralized/Centralized approaches for interoperability

Table 5.14: Is there a centralized system between government health care centers and private hospitals

Hospitals IT Managers	The answer
Al-Ahli Hospital	All of them answered that there is no centralized system for managing and storing electronic health records in Palestine.
Mohammad Al	
The governmental hospital of Hebron (Alia)	
Palestine medical complex (PMC)	

Table 5.15: What do you think of any centralized or decentralized approach that could be beneficial for interoperability between government healthcare centers and private hospitals?

Hospitals IT Managers	The answer
Al-Ahli Hospital	He praised the importance of the centralized system in all countries, but there is a problem in the central system that if one of its components breaks down, the entire system will be disrupted, contrariwise in a decentralized system if one of its components fails, the other components will be preserved.
Mohammad Al	

The governmental hospital of Hebron (Alia)	They unanimously said that the decentralized system is the system that can be Achieved in Palestine because all health institutions in Palestine have different systems and databases.
Palestine medical complex (PMC)	

Table 5.16: Do you support the adoption of a decentralized environment in implementing interoperability?

Hospitals IT Managers	The answer
Al-Ahli Hospital	They focused on supporting the adoption of the decentralized environment in achieving interoperability in Palestine.
Mohammad Al	
The governmental hospital of Hebron (Alia)	
Palestine medical complex (PMC)	

5.11 Security risks and patient privacy for interoperability

Table 5.17: Do you have procedures to preserve the privacy of patients, and what are these procedures, if any?

Hospitals IT Managers	The answer
Al-Ahli Hospital	There are complete procedures to preserve patient privacy even at the level of physicians and services. Every service or data can be accessed by authorized persons only, moreover, there is an audit of all requests made on the system.
Al-Meezan hospital	The procedures are carried out at the level of protection systems on servers and firewalls.
The governmental hospital of Hebron (Alia)	There are complete integrated procedures to preserve patients' privacy by defining the permissions of users in addition to penetration and protection programs.
Palestine medical complex (PMC)	Some procedures follow a protocol system for the distribution of permissions, each employee is granted specific permissions by an official decision from the hospital director. Also, the permissions are constantly being subordinated.

Table 5.18: What privacy and security measures are in place to protect patient information?

Hospitals IT Managers	The answer
Al-Ahli Hospital	

Al-Meezan hospital	Their answers were similar in that all procedures and storage are at the level of the organization's servers itself, and no data is stored on tablets or computers; so, the data is only accessed through the organization's internal network. it cannot be accessed from the Internet or any external network. And there is an audit system that records all requests on the systems.
The governmental hospital of Hebron (Alia)	
Palestine medical complex (PMC)	

Table 5.19: Does the hospital conduct annual security risk assessments?

Hospitals IT Managers	The answer
Al-Ahli Hospital	The annual evaluations are conducted to clarify and improve the distributed permissions, besides clarifying needs and raising awareness and pointing out the methods for using information safely.
Al-Meezan hospital	They answered that there is no assessment of the security risks annually
The governmental hospital of Hebron (Alia)	
Palestine medical complex (PMC)	He answered that the Palestinian Ministry of Health does this annually

5.12 Interoperability initiatives, agreements, and proposals

Table 5.20: Are there initiatives, suggestions, or interoperability agreements between healthcare organizations?

Hospitals IT Managers	The answer
Al-Ahli Hospital	Both answered that there are no interoperability initiatives in Palestine.
Al-Meezan hospital	
The governmental hospital of Hebron (Alia) -	There is an initiative by the computer unit in the Ministry of Health, but the initiative is stopped due to the covid-19 pandemic.
Palestine medical complex (PMC)	There are very timid initiatives because the situation in the Palestinian Ministry of Health is unstable in terms of infrastructure.

5.13 The role of the Ministry of Telecommunications and Information Technology (MTIT) in interoperability.

Table 5.21: Do you think that the Ministry of Telecommunications and Information Technology can bridge the gap in interoperability between health care centers and how is it looking forward to this role?

Hospitals IT Managers	The answer
Al-Ahli Hospital-	Governmental dependency is the main factor in interoperability.

Al_Ahli hospital	
Al-Meezan hospital	The government could do that.
The governmental hospital of Hebron (Alia)	Answered that he doesn't know.
Palestine medical complex (PMC)	Yes, if there is a secure network for data exchange and the availability of resources as well as the availability of the necessary decisions.

Table 5.22: Do you think that the interoperability process through the Ministry of Telecommunications and Information Technology will be secure and reliable?

Hospitals IT Managers	The answer
Al-Ahli Hospital-Al_Ahli hospital	The role of the Ministry of Communications depends on the decisions, and tools used, in addition to the mechanism of analysis, and the procedures to provide security and health information protection.
Al-Meezan hospital	The Ministry of Telecommunications is capable to do it.
The governmental hospital of Hebron (Alia)	Yes, but within specific policies and laws by the cabinet

Palestine medical complex (PMC)	Yes, if it relied on data security and reliability standards

5.14 Infrastructure for interoperability

Table 5.23: Do you have an infrastructure to help achieve interoperability, explain.

Hospitals IT Managers	The answer
Marwan Shehade	They have sufficient infrastructure for interoperability
Al-Meezan hospital	They have the infrastructure but it needs to be developed
The governmental hospital of Hebron (Alia)	Both answered that the Palestinian Ministry of Health has the infrastructure, but it needs to be developed and updated to support interoperability.
Palestine medical complex (PMC)	

5.15 Support a security proposal or framework that supports interoperability

Table 5.24: Can you support any security proposal or framework that supports interoperability with a clarification?

Hospitals IT Managers	The answer
Al-Ahli Hospital- Al_Ahli hospital	Yes, through the Palestinian government.
Al-Meezan hospital	Yes

The governmental hospital of Hebron (Alia)	Yes, with a desktop application, a website, and a smartphone application to obtain information through
Palestine medical complex (PMC)	Yes, through the Palestinian Ministry of telecommunications, the only institution that can be trusted for interoperability.

5.16 The transition from paper medical records to electronic health records

Table 5.25: Are physician documents (e.g., progress notes, consultation notes, discharge summaries, list of problems/diagnosis, etc.) performed electronically?

Hospitals IT Managers	The answer
Al-Ahli Hospital-Al_Ahli hospital	All documents and procedures they have are done electronically
Al-Meezan hospital	They have a system under development and the documental part is done electronically but another one is paper.
The governmental hospital of Hebron (Alia)	All documents in the Palestinian Ministry of Health and data are stored and managed electronically.
Palestine medical complex (PMC)	

Table 5.26: Are electronic transactions made on the system recorded for future reference for audit and accountability purposes?

Hospitals IT Managers	The answer
Al-Ahli Hospital	They answered yes, and in the Ministry of Health nothing is deleted from the electronic health record and there is no policy to delete files after some time.
Al-Meezan hospital	
The governmental hospital of Hebron (Alia)	
Palestine medical complex (PMC)	

5.17 Interviews Summary

Looking at the analyzes of the previous interviews, we find many interoperability issues common to the public and private health sectors, and some are different. The idea of interoperability and its importance is well known to the public and private sectors, and the health information systems are similar in content and differ in programs and systems. The public sector has a unified system and database in all government hospitals, while the private sector has a private system that differs from one hospital to another. Everyone emphasized the importance of interoperability, in terms of developing the quality of health care, which benefits the patient, health care providers, and health workers. All interviewees agreed that there are major challenges facing interoperability in Palestine, the most important of which

are the lack of policies and laws regulating this field and the lack of a secure data exchange system and adequate infrastructure necessary for interoperability, in addition to the importance of the Palestinian government's sponsorship of interoperability represented by the Palestinian Ministry of Telecommunications and the Ministry of Health, and everyone emphasized on the importance of deploying international standards for the achievement of interoperability, which include standards for security and privacy of exchanged information and other important standards such as the HL7 standard. Every institution has special procedures to maintain data privacy, the most important among these procedures is the distribution of authentication, audit records, and various security issues. The interviewees confirmed that the proposed framework should work in a decentralized environment that is applicable in Palestine because there is no unified national database.

ICT is the base to achieve interoperability. The infrastructure in the public sector is not ready and needs to be developed and configured for interoperability. In the private sector, most of them have an infrastructure that can interoperate – with some modifications and extra tools- except for Al-Mizan Hospital, they have a system under development. All interviewees are supportive of any secure interoperability framework in Palestine, they all agreed on the importance of privacy and information security for exchanged electronic health records.

5.18 Sample Characteristics

The current study included a total of (2350) employees, from whom a total of (140) completed the questionnaires (participation rate of 6%). As shown in Table 5.27 and figures from 5.1-5.7, males were more representative than females (*n*=79; 56.4%) vs. (*n*=61; 43.6%). In addition, the highest percentage was for the age group 26-40 (*n*=82, 58.6%), and the nursing percentage was the highest in the medical specialties represented (*n*=84, 60%), and

the workplace ratio was similar in all hospitals of the study sample, which consisted of (17% to 20%), and the years of experience from 1-4 years represented the highest percentage (*n*=76, 54.3%). Also, the number of years of using the health information system from 1-4 years was the highest (*n*=47, 33.6%), and the intensive care unit was the highest among the other departments in the sample as it represented (*n*=23, 16.4%) of all departments.

Table 5.27: Demographic Information (n=140).

Variable	Sub-variable	Frequency	Percent %
Gender	Male	79	56.4
	Female	61	43.6
Age	Less than 25	54	38.6
	26-40	82	58.6
	55-41	3	2.1
	More than 56	1	0.7
Medical specialty	Physician	14	10.0
	Nurse	84	60.0
	Resident physician	3	2.1
	Pharmacist	6	4.3
	Laboratory technician	10	7.1
	Anesthetist	1	0.7
	Midwife	6	4.3
	Radiation therapist	7	5.0
	Accounting	2	1.4

	Radiology Technician	4	2.9
	Respiratory Therapist	1	0.7
	Medical Imaging	1	0.7
	Quality	1	0.7
Place of your current work	Al-Ahli Hospital	29	20.7
	The governmental hospital of Hebron (Alia)	28	20.0
	Palestine red crescent society hospital	2	1.4
	Al-Meezan hospital	24	17.1
	Palestine medical complex (PMC)	30	21.4
	Istishari Arab hospital	27	19.3
Years of experience	1-4	76	54.3
	5-8	33	23.6
	9-12	15	10.7
	More than 12	16	11.4
Years of using HIS system in your work	Less than 1	32	22.9
	1-4	47	33.6
	5-8	35	25.0
	More than 8	17	12.1
	None	9	6.4

Department of your work	Neonatal	8	5.7
	Infection control	1	0.7
	Hematology	2	1.4
	Internal medicine	6	4.3
	Pediatrics	5	3.6
	General surgery	11	7.9
	Cardiovascular	5	3.6
	Obstetrics / Gynecology	3	2.1
	Maternity	6	4.3
	Nephrology	1	0.7
	Pharmacy	7	5.0
	Radiotherapy	2	1.4
	Emergency	8	5.7
	Intensive care unit (ICU)	23	16.4
	Coronary care unit (CCU)	14	10.0
	Radiology	16	11.4
	Neurology	1	0.7
	Radiology	3	2.1
	Radiology Technician	3	2.1
	Kidney Unit	2	1.4
	Medicine/Medical	4	2.9
	Laboratory	5	3.6

	Out Patient Clinic	1	0.7
	Medical analysis	1	0.7
	Quality	1	0.7
	Nursing Home	1	0.7

Figures from 5.1 to 5.7 show the results of demographic data, in terms of gender, age, medical specialty, Place of your current work, years of experience, years of using HIS system in your work, and department of your work.

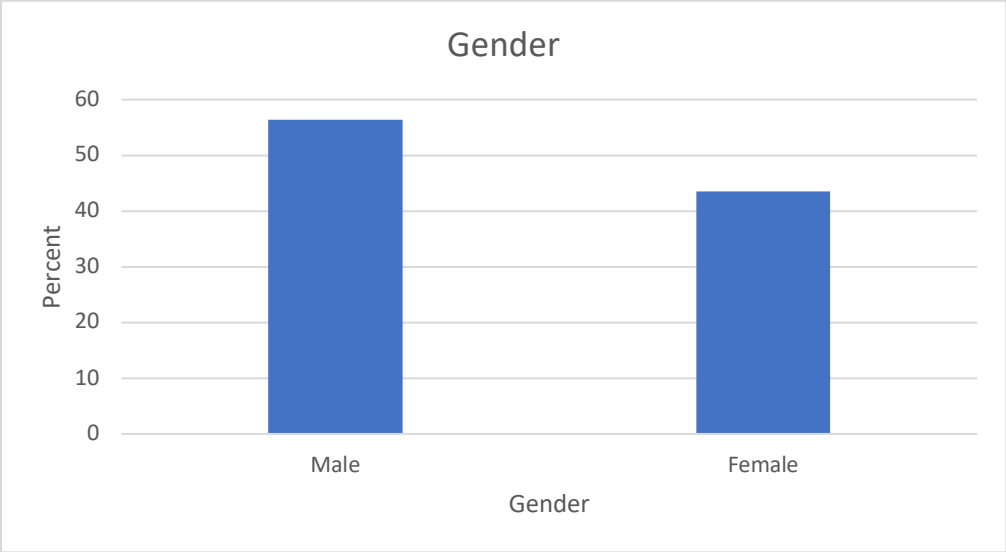

Figure 5.1: Gender

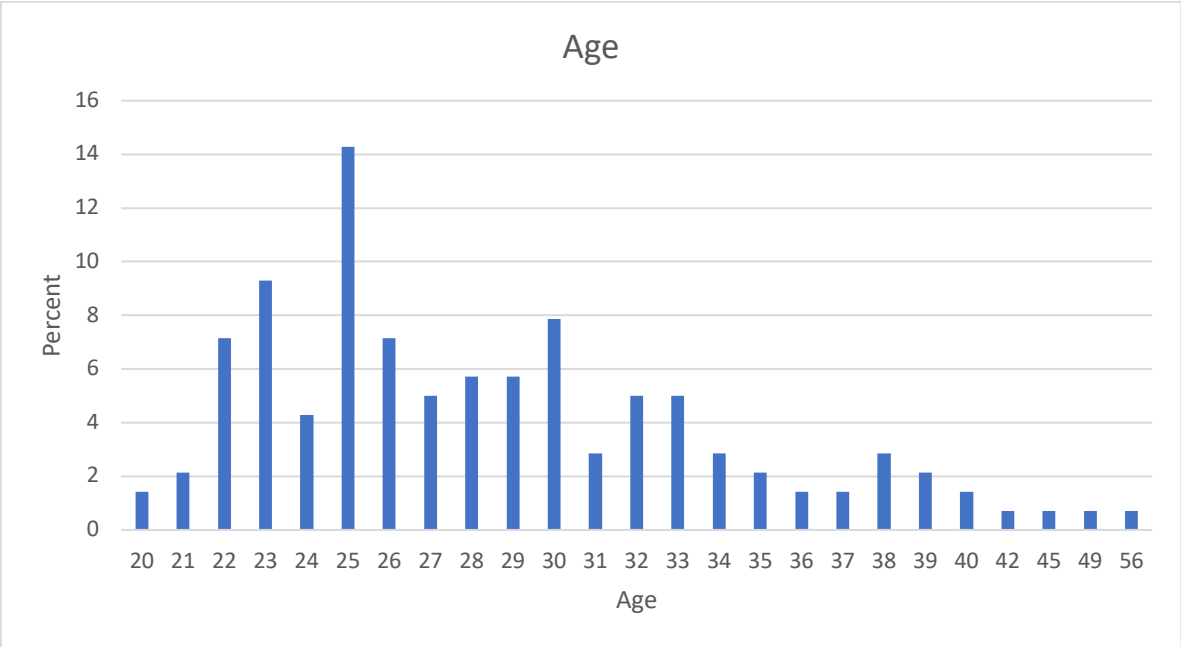

Figure 5.2: Age

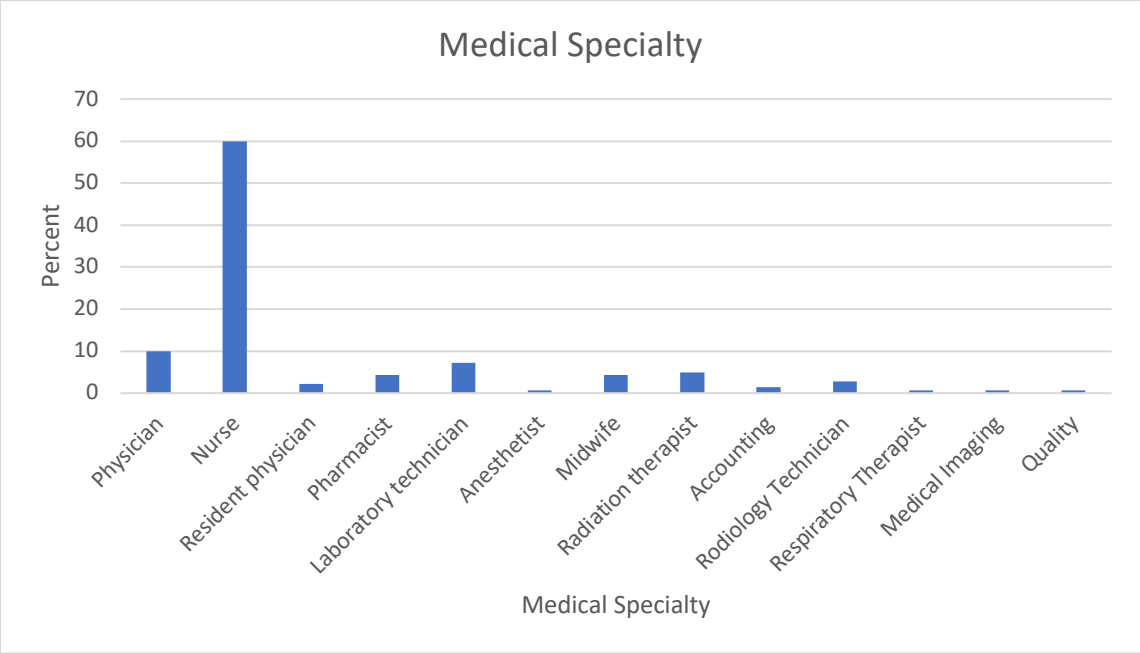

Figure 5.3: Medical Specialty

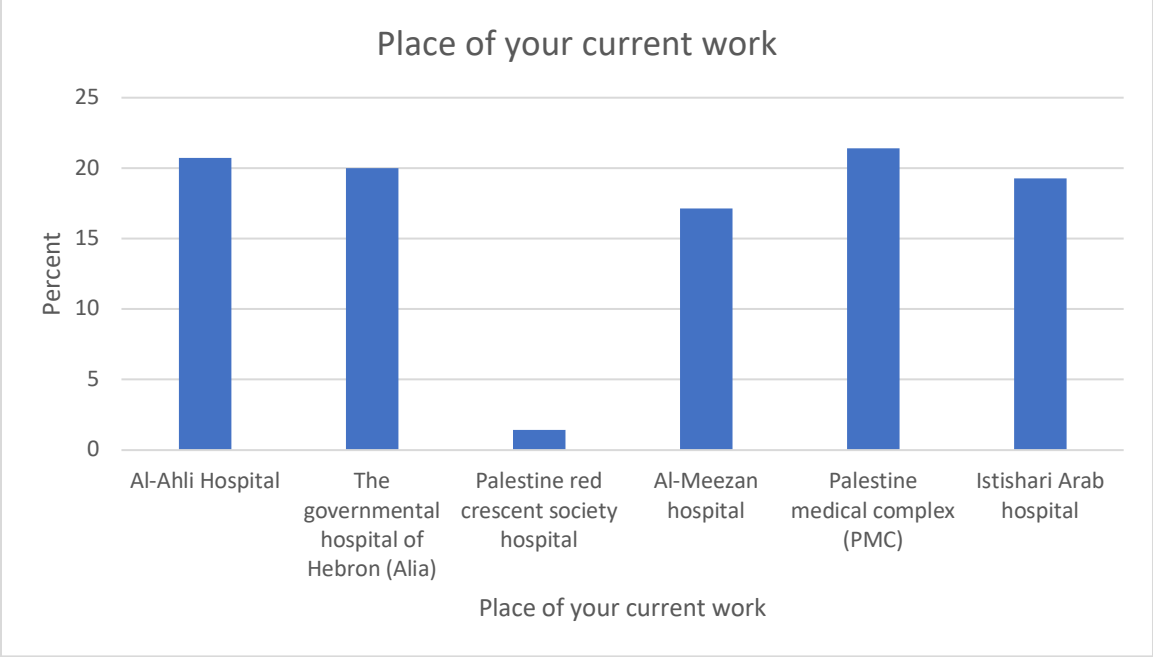

Figure 5.4: Place of your current work

Figure 5.5: Year of experience

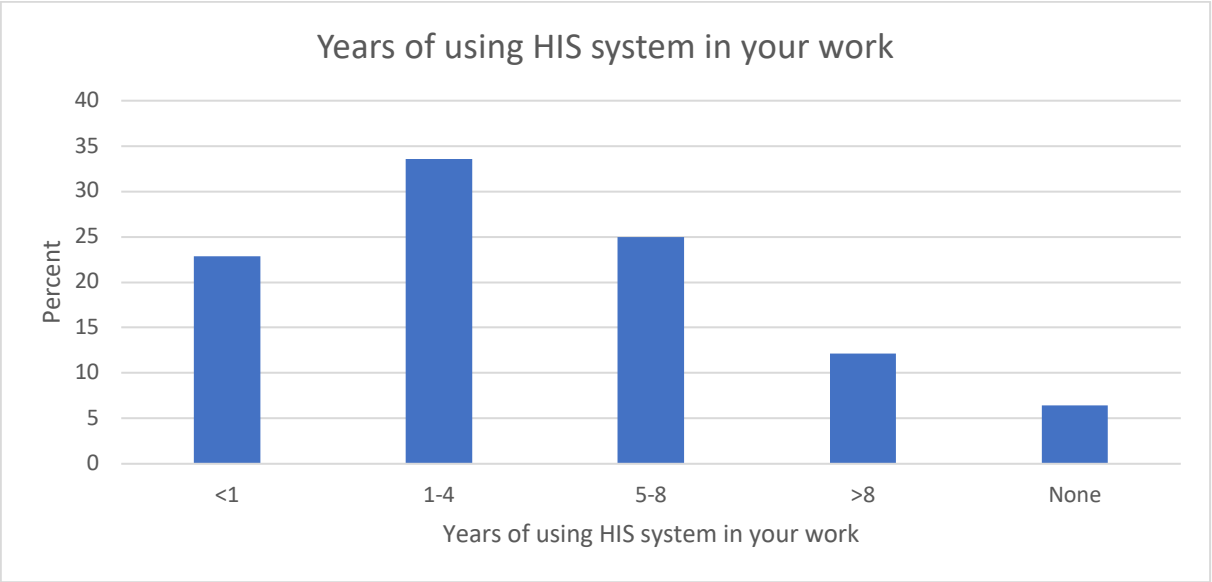

Figure 5.6: Year of using HIS system in your work

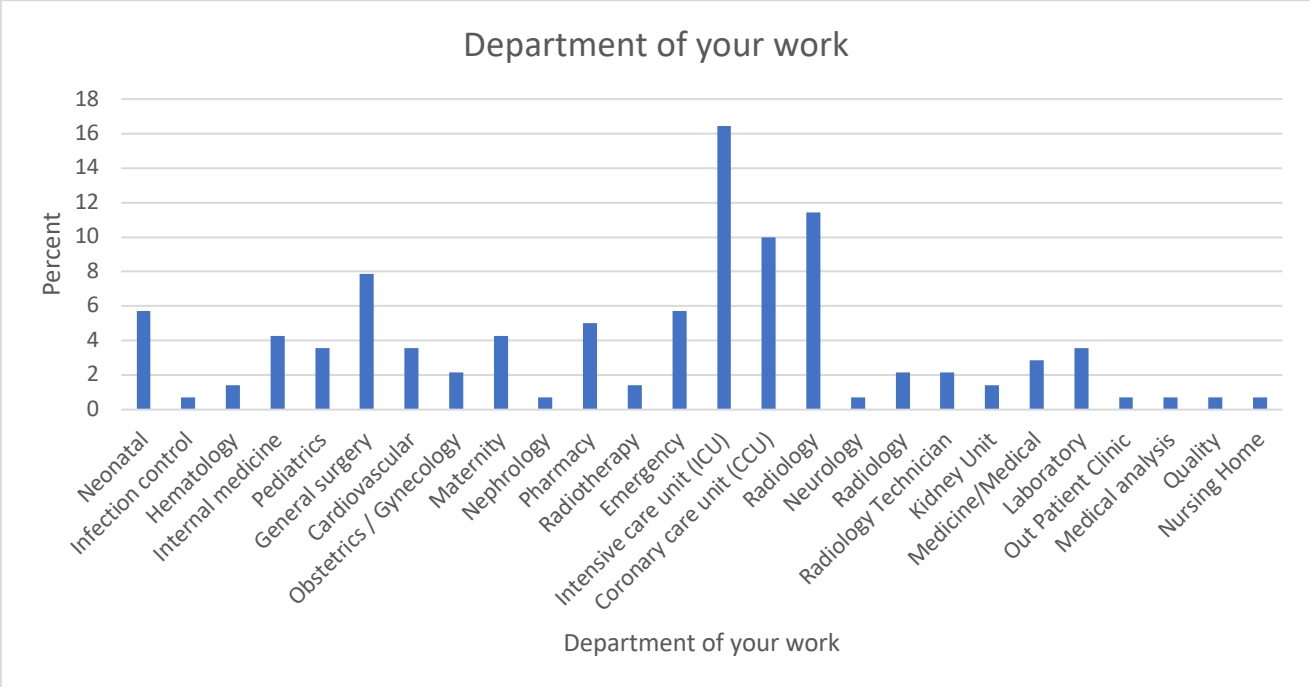

Figure 5.7: Department of your work

5.19 Questionnaire Analysis

The researcher used the basic statistical tests “mean, percentage, and standard deviation" to analyze the questionnaire items.

5.20 Data Exchange Condition

This section aims to verify how medical data is currently shared between private and public hospitals in Palestine. The data collected through the questionnaire was subjected to frequency, in other words, the response of health workers was added together to find the highest frequency, after which the results were presented in the form of a percentage.

5.21 The first sub-question: Outside patient information typically sent and received from other hospitals in Palestine using (one or more answers)?

To answer the previous question, the means, percentages, and standard deviations of the outside patient information are typically sent and received from other hospitals in Palestine (Table 5.28).

The data shown in Table 5.28 indicates that sending and receiving patient information from other hospitals in Palestine is in close proportions between the paper system with a percentage (n=74, 52.9%) and the electronic system with a percentage (65, 46.4%), and this explains that the transition from the paper system to the electronic system in Palestine is in progress.

Table 5.28: Outside patient information is typically sent and received from other hospitals in Palestine.

Variable	Sub-variable	Frequency	Percent %
Paper	Yes	74	52.9
	No	65	46.4
Fax	Yes	7	5.0
	No	133	95
Email	Yes	20	14.3
	No	120	85.7
Computer System	Yes	65	46.4
	No	73	52.1
Portable Storage Medium	Yes	3	2.1
	No	137	97.9
Cloud Storage Services	Yes	2	1.7
	No	137	97.9

5.22 The second sub-question: The usual time frame for receiving EHR information?

To answer the previous question, the means, percentages, and standard deviations of the usual time frame for receiving EHR information, as shown in Table 5.29.

The data shown in Table 5.29 indicates that the usual time frame for receiving EHR information is 24 hours at a higher rate (n=69, 49.3%) and then followed by information within an hour (n=51, 36.4%).

Table 5.29: The usual time frame for receiving EHR information

Variable	Sub-variable	Frequency	Percent %
The usual time frame for receiving EHR information?	Within one hour	51	36.4
	Within 24 hours	69	49.3
	From 2 to 3 days	7	5
	More than 3 days	13	9.3

5.23 The third sub-question: I think interoperability between government healthcare centers and private hospitals is beneficial for patients, professionals, and other healthcare stakeholders.

To answer the previous question, the means, percentages, and standard deviations of the interoperability between government healthcare centers and private hospitals are beneficial for patients, professionals, and other healthcare stakeholders, as shown in Table 5.30.

The data shown in Table 5.30 indicates near-consensus on the importance of interoperability between health care institutions and that it is beneficial for patients,

professionals and other stakeholders in health care and the answer rate of yes is very high (n=133, 95%).

Interviewees agreed with questionnaire respondents about the importance of interoperability and that the benefits accrue directly to the patient in terms of reducing costs and reducing the duplicate of medical examinations, as well as sharing experiences among employees and improving the quality of health care.

Table 5.30: I think interoperability between government healthcare centers and private hospitals is beneficial for patients, professionals, and other healthcare stakeholders

Sub-variable	Frequency	Percent %
Yes	133	95
No	3	2.1
I don't know	4	2.9

5.24 The fourth sub-question: I agree that the information and communication technology (ICT) platform can play a vital role in obtaining interoperability between public and private healthcare centers and hospitals.

To answer the previous question, the means, percentages, and standard deviations agree that the information and communication technology (ICT) platform can play a vital role in obtaining interoperability between public and private healthcare centers and hospitals, as shown in Table 5.31.

The data shown in Table 5.31 indicates almost unanimity that the ICT platform can play a vital role in achieving interoperability between private and public health centers in Palestine, and the answer rate of yes was very high (n=126, 90).

In the analysis of interviews with information technology officials, their answers coincide with questionnaire answers about the importance of the role of information and communication technology in achieving interoperability among Palestinian health care centers.

Table 5.31: I agree that the information and communication technology (ICT) platform can play a vital role in obtaining interoperability between public and private healthcare centers and hospitals

Sub-variable	Frequency	Percent %
Yes	126	90
No	9	6.4
I don't know	4	2.9

5.25 The fifth sub-question: I think the systems to be linked should apply the standards such as clinical document architecture (CDA), health level 7 (HL7), and privacy and security Standards.

To answer the previous question, the means, percentages, and standard deviations of the systems to be linked should apply the standards such as clinical document architecture (CDA), health level 7 (HL7), and privacy and security standards, as shown in Table 5.32.

The data shown in Table 5.32 indicates almost unanimity that interoperability should apply international standards that guarantee privacy and security standards (CDA and HL7), and the yes answer rate was very high (n=126, 90).

It is no doubt that the interviewee agreed with the questionnaire respondents in their answers about the importance of standards that should be used in interoperability, especially security and privacy standards, and data exchange standards such as HL7.

Table 5.32: I think the systems to be linked should apply the standards such as clinical document architecture (CDA), health level 7 (HL7), privacy and security Standards

Sub-variable	Frequency	Percent %
Yes	126	90
No	4	2.9
I don't know	9	6.4

5.26 The sixth sub-question: I agree that consistency of shared data is important during interoperability.

To answer the previous question, the means, percentages, and standard deviations agree that the consistency of shared data is important during interoperability, as shown in Table 5.33. In the data shown in Table 5.33, the response with a high percentage indicates that the consistency of the shared data is important during interoperability that is, a standardized form of the data that is exchanged, and the percentage of the yes answer was high (n=119, 85%).

Table 5.33: I agree that consistency of shared data is important during interoperability

Sub-variable	Frequency	Percent %
Yes	119	85
No	8	5.7
I don't know	12	8.6

5.27 The seventh sub-question: I agree that the government should be somehow involved in the process of interoperability among health care institutions.

To answer the previous question, the means, percentages, and standard deviations agree that the government should be somehow involved in the process of interoperability among health care institutions, as shown in Table 5.34.

The data shown in Table 5.34 indicate that the Palestinian government should have a clear role and participate in interoperability between health care institutions in Palestine because it owns the largest health sector, which is the public sector, and the rate of answering yes is very high (n=124, 88.6%).

Table 5.34: I agree that the government should be somehow involved in the process of interoperability among health care institutions

Sub-variable	Frequency	Percent %
Yes	124	88.6
No	8	5.7
I don't know	6	4.3

5.28 The ninth sub-question: I believe that health information systems are an alternative to traditional paper-based systems.

To answer the previous question, the means, percentages, and standard deviations of the belief that health information systems are an alternative to traditional paper-based systems, as shown in Table 5.35.

The data shown in Table 5.35 indicates that the health information systems are answered with a high percentage of yes, that health information systems are an alternative to paper systems, and this is clear evidence of the preference for using technology in the management of electronic health records, and the percentage of answering yes was high (n=114, 81.4%).

Table 5.35: I believe that health information systems are an alternative to traditional paper-based systems

Sub-variable	Frequency	Percent %
Yes	114	81.4
No	13	9.3
I don't know	7	5.0

5.29 Secure interoperability between private and public health care institutions in Palestine from the point of view of health workers in Palestine.

The data presented in Table 5.36 and figure 5.8, summarizes the results of the evaluation of security interoperability in Palestine from the point of view of health workers, and the results were of a high degree for all studied domains with a percentage (M=3.73, 74.6%) and this results from answers the research questions. The technical requirements for interoperability obtained the highest percentage (M=3.90, 78.8%) Then followed by the data that can be exchanged through interoperability with a percentage (M=3.75, 75.06%) and then followed by the benefits of interoperability with a percentage (M=3.74, 74.79%) and then the challenges of interoperability with a percentage (M=3.52, 70.38%).

Table 5.36: Interoperability between public and private health care institutions in Palestine from the point of view of health workers in Palestinian health institutions.

Item No.	Rank	Domain	Mean	%	S. D	Degree
1	4	Interoperability Challenges	3.52	70.38	1.110	High
2	3	Interoperability Benefits	3.74	74.79	1.08	High
3	2	Interoperability Requirements	3.75	75.06	1.032	High
4	1	Technical interoperability requirements	3.90	78.08	1.1098	High
All Domains			**3.73**	**74.6**	**1.08**	**High**

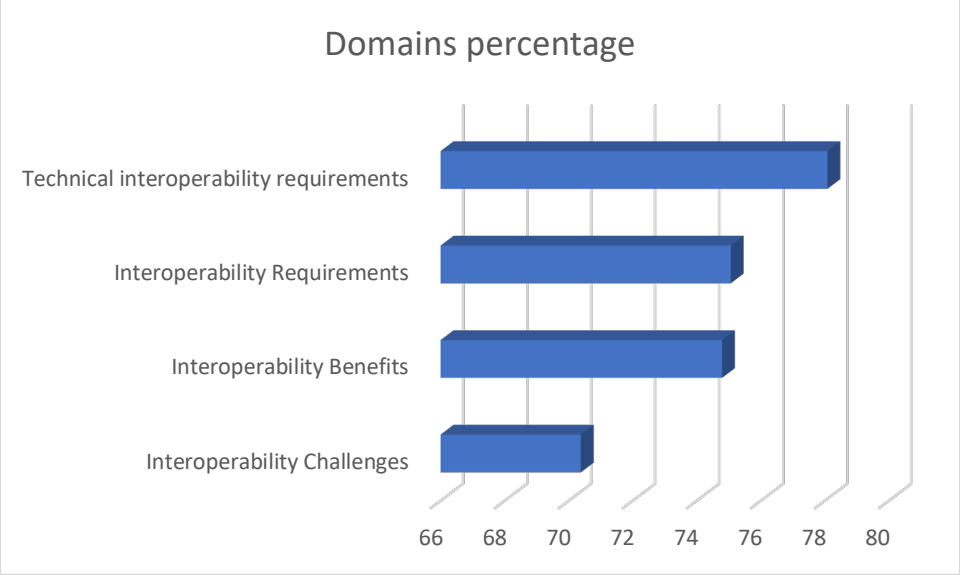

Figure 5.8: Questionnaire domains averages

5.30 Domain one: Interoperability Challenges

The sub-question: In your opinion, answer the following questions by selecting the appropriate state for each of the following suggested interoperability challenges.

This section aims to explore the challenges that have more impact on the interoperability between private and public health care centers in Palestine. To analyze the collected data to answer these questions, the researcher used mean and standard deviation measures, and percentages, the total degree based on the 5-point Likert scale defined in Section (4.14) was also displayed. The results of the analysis are presented in Table 5.37

Table 5.37: Interoperability Challenges

Rank	Item No.	Item (Interoperability Challenges)	Mean	Percentage %	S.D	Degree
6	1	Interfacing	3.53	70.6	1.112	High
3	2	Integration of different applications.	3.67	73.4	1.004	High
2	3	Privacy of information	3.70	74	1.140	High
1	4	Authentication and auditing.	3.76	75.2	1.067	High
4	5	The implementation cost of an interoperable system.	3.62	72.4	0.983	High
5	6	Security of shareable information.	3.56	71.2	1.155	High
8	7	Absence of infrastructure for information exchange.	3.44	68.8	1.121	High
9	8	Absence of trust in outside information	3.34	66.8	1.200	Moderate
7	9	The hospital has strict policies regarding information sharing.	3.48	69.6	1.108	High
10	10	Resistance to the use of a new computer-based system by staff members	3.09	61.8	1.216	Moderate
Interoperability Challenges			**3.52**	**70.38**	**1.110**	**High**

The results in Table 5.37 indicate that the most influential interoperability challenges are authentication and auditing with a mean of 3.76 which is a high degree with a standard deviation of 1.067 which denotes those responses, on average, were a little over one point away from the mean. Followed by the privacy of information has a mean of 3.70 which is a

high degree with a standard deviation of 1.140 denotes those responses, on average, were a little over one point away from the mean. They also see the integration of different applications as a strong challenge for electronic data exchange as an obtained mean of 3.70, which is a high degree with standard deviations of 1.140, which denote those responses, on average, were a little over one point away from the mean. They also see the Implementation cost of an interoperable system, as a strong challenge for electronic data exchange with a mean of 3.62, which is a high degree, and with a standard deviation of 0.983, which denotes that responses slightly deviate from the mean. The five, six, seven, and 8 statements of challenges about the security of shareable information and interfacing and the hospital has strict policies regarding information sharing, and absence of infrastructure for information exchange, with means of 3.56, 3.53, 3.48, 3.44 respectively, which is high degree and with standard deviations of 1.155, 1.112, 1.108 and 1.121 respectively. The last two statements of challenges about the absence of trust in outside information and resistance to using a new computer-based system by staff members were obtained by means equal to 3.34 and 3.09 respectively, which is the moderate degree, and standard deviations of 1.200 and 1.216 respectively, which denote those responses, on average, were a little over two points away from the mean.

5.31 Domain two: Interoperability Benefits

The sub-question: In your opinion, answer the following questions by selecting the appropriate state for each of the following suggested interoperability benefits.

This section aims to verify whether health workers are highly aware of the benefits of interoperability as part of the forces to achieve interoperability between private and public healthcare institutions in Palestine. The data collected through the questionnaire and

interviews were analyzed to answer these questions, the researcher used mean and standard deviation measures. The results were displayed based on the total degree of the 5-point Likert scale defined in Section 4.14. Analysis results are presented in Table 5.38.

Table 5.38: Interoperability Benefits

Rank	Item No.	Item (Interoperability Benefits)	Mean	Percentage %	S.D	Degree
8	1	Interoperability will benefit the patients.	3.75	75	1.151	High
3	2	Interoperability will benefit the stakeholders.	3.85	77	1.081	High
4	3	Interoperability will benefit healthcare professionals.	3.84	76.8	1.136	High
13	4	The overall cost of the patient's treatment will be reduced.	3.48	69.6	1.157	High
10	5	The quality of patient care will be improved.	3.68	73.6	1.083	High
6	6	Safety of patient care will be better guaranteed.	3.78	75.6	1.080	High
9	7	Interoperability will help to generate a more accurate diagnosis	3.73	74.6	1.162	High

1	8	Interoperability will help to reduce duplication of lab and imaging tests.	3.88	77.6	1.039	High
7	9	Interoperability will help in preventing drug-drug interactions.	3.77	75.4	1.091	High
12	10	Interoperability will reduce time in patient sessions.	3.53	70.6	1.145	High
10	11	Interoperability will help Improve decision-making.	3.68	73.6	1.060	High
2	12	Interoperability will help avoid filling multiple forms.	3.86	77.2	0.982	High
11	13	Interoperability will help reduce health care costs.	3.67	73.4	0.997	High
7	14	Interoperability will improve the reputation of hospitals and clinics.	3.77	75.4	0.993	High
5	15	Sharing experiences and knowledge between healthcare staff.	3.82	76.4	1.043	High
Interoperability Benefits			**3.74**	**74.79**	**1.08**	**High**

The results in the above table indicate that the most influential interoperability benefit is interoperability will help to reduce duplication of lab and imaging tests with a mean of 3.88 which is a high degree with a standard deviation of 1.039 that denotes that responses, on average, were a little over one point away from the mean. Followed by interoperability will help to avoid filling multiple forms with a mean of 3.86 which high degree with a standard deviation of 0.982 denotes that responses slightly deviate from the mean. They also see that the interoperability will benefit the stakeholders as a strong benefit was obtained by a mean of 3.85, which is a high degree with standard deviations of 1.081, which denote that responses, on average, were a little over one point away from the mean. They also see that the interoperability will benefit the healthcare professionals, the as strong benefit for interoperability was obtained by a mean of 3.84, which is a high degree, and a standard deviation of 1.136, which denotes that responses, on average, were a little over one point away from the mean. Also, sharing experiences and knowledge between healthcare staff was obtained with a mean of 3.82, which is a high degree, and a standard deviation of 1.043 which denotes that responses, on average, were a little over one point away from the mean. The last ten statements included, that the safety of patient care will be better guaranteed, interoperability will help in preventing drug-drug interactions, Interoperability will improve the reputation of hospitals and clinics, interoperability will benefit the patients, interoperability will help to generate a more accurate diagnosis, the quality of patient care will be improved, Interoperability will help to improve decision-making, interoperability will help to reduce health care costs, interoperability will reduce time in patient sessions, and the overall cost for the patient's treatment will be reduced, were obtained by means equal to 3.78,

3.77, 3.77, 3.75, 3.73, 3.68, 3.68, 3.67, 3.53, and 3.48 respectively, which is a high degree and standard deviations of 1.080, 1.091, 0.993, 1.151, 1.162, 1.083, 1.06, 0.997, 1.145, and 1.157 respectively, which denote that responses, on average, slightly deviate or a little over one point away from the mean.

5.32 Domain Three: Interoperability Requirements

Section A: What patient information do you want to electronically exchange?

To answer the previous question, the means, percentages, and standard deviations of the Interoperability of patient information requirements are arranged in order of importance, as shown in Table 5.39.

This section aims to verify the most important data that should be exchanged through interoperability and which is of greatest benefit to the patient. The data collected through questionnaires were analyzed to answer these questions, and the total degree based on the 5-point Likert scale defined in Section 4.14 will be displayed. Analysis results are presented in Table 5.39.

Table 5.39: Interoperability of patient information requirements

Rank	Item No.	Item (Interoperability patient information requirements)	Mean	Percentage %	S.D	Degree
4	1	Medical history	3.81	76.2	1.015	High
5	2	Vital signs.	3.74	74.8	0.972	High
3	3	Medication list.	3.86	77.2	0.976	High
1	4	Allergy list.	3.95	79	0.992	High
2	5	Laboratory results.	3.91	78.2	1.000	High

3	6	Diagnostic imaging results.	3.86	77.2	1.029	High
6	7	Discharge instructions/ notes.	3.73	74.6	1.010	High
7	8	Implanted medical devices list.	3.71	74.2	1.055	High
9	9	Full health record (HR) information.	3.55	71	1.146	High
10	10	Personal information.	3.52	70.4	1.122	High
6	11	Patient's medical diagnoses	3.73	74.6	1.010	High
8	12	Referral services.	3.68	73.6	1.041	High
5	13	Family history	3.74	74.8	1.048	High
Interoperability of patient information requirements			**3.75**	**75.06**	**1.032**	**High**

Table 5.39 shows that the total degree of health workers' agreement on the need to interchange all kinds of patient information is strongly agreed upon, with a mean of 3.75, which indicates a high need for interchanging patient information.

Health workers respondent strongly agree on the need to electronically exchange allergy lists, laboratory results, medication lists, laboratory results, medication lists, diagnostic imaging results, medical history, vital signs, family history, discharge instructions/ notes, patient's medical diagnoses, implanted medical devices list, referral services, full health record (HR) information, and personal information. As their means were 3.95, 3.91, 3.86, 3.86, 3.81, 3.74, 3.73, 3.73, 3.71, 3.68, 3.55, and 3.52 respectively. The standard deviation values were 0.992, 1.00, 0.976, 1.029, 1.015, 0.972, 1.010, 1.01,0, 1.055, 1.041, 1.146, and 1.122 respectively, which indicate that responses slightly deviate or a little over one point away from the mean.

Section B: Technical interoperability requirements: What is your opinion about the necessity of the following items and properties for the successful adoption of interoperability?

This section aims to verify the most important operational, technical, and infrastructure requirements that are the skeleton of interoperability through ICT. The data collected through the questionnaire and interviews were analyzed to answer these questions. The data collected through questionnaires were analyzed to answer these questions. The total degree based on the 5-point Likert scale defined in Section 4.14 were also displayed. Analysis results are presented in Table 5.40.

Table 5.40: Technical interoperability requirements

Rank	Item No.	Item (Technical interoperability requirements)	Mean	Percentage %	S.D	Degree
10	1	The necessity of having trusted third-party managing interoperability between healthcare organizations.	3.74	74.8	1.147	High
7	2	The ability of the MTIT to manage interoperability.	3.87	77.4	1.007	High
11	3	The ability of the MTIT as a third party to maintain information security.	3.71	74.2	0.976	High
6	4	Using the necessary hardware, and equipment to maintain the confidentiality of information interoperability.	3.90	78	0.995	High

2	5	Using the necessary software to maintain the confidentiality of information interoperability.	4.01	80.2	1.176	High
8	6	The need for dedicated computers & tablets to be used in interoperable systems.	3.85	77	0.996	High
3	7	Need software programs for better use of interoperability.	3.99	79.8	0.996	High
9	8	Need mobile applications for better utility of interoperability.	3.79	75.8	1.084	High
5	9	The need for a dedicated internet connection for users of interoperable systems.	3.92	78.4	1.094	High
1	10	Need for dedicated information technology staff for troubleshooting.	4.05	81	1.018	High
1	11	Need training for healthcare professionals to use the system.	4.05	81	1.014	High
4	12	Need the establishment of a help desk to follow up on system problems and take the appropriate action.	3.97	79.4	1.115	High
Technical interoperability requirements			**3.90**	**78.08**	**1.1098**	**High**

Table 5.40 shows that the total degree of health workers' agreement on the need for technical interoperability requirements, is strongly agreed, with a mean of 3.90, which indicates a high need for technical requirements.

Respondent health workers strongly agree on all statements, the need for technical interoperability requirements, need for dedicated information technology staff for

troubleshooting, need training for healthcare professionals to use the system, using the necessary software to maintain the confidentiality of information interoperability, need software programs for better use of interoperability, need the establishment of a help desk to follow-up system problems and take the appropriate action, the need for dedicated internet connection for users of interoperable systems, using the necessary hardware, equipment to maintain the confidentiality of information interoperability, the ability of the MTIT to manage interoperability, need for dedicated computers & tablets to be used in interoperable systems, need mobile applications for better utility of interoperability, the necessity of having a trusted third-party managing interoperability between healthcare organizations, and the ability of the MTIT as a third party to maintain information security. As their means were 4.05, 4.05, 4.01, 3.99, 3.97, 3.92, 3.90, 3.87, 3.85, 3.79, 3.74, and 3.71 respectively. The standard deviation values were 1.018, 1.014, 1.167, 0.996, 1.115, 1.094, 0.995, 1.007, 0.996, 1.084, 1.147, and 0.976 respectively, which indicate that responses slightly deviate or a little over one point away from the mean.

Chapter 6: Proposed Framework

6.1 Overview

Based on a literature review and a study of the current situation of secure interoperability between healthcare institutions in Palestine, it was found that the current systems in private and public healthcare institutions do not comply with any of the important standards for interoperability and the exchange of electronic health records among these institutions, and there are no policies or laws regulating this, so the researcher suggested using the accredited framework for interoperability among the various Palestinian governmental institutions owned by the Palestinian Ministry of Telecommunications and Information Technology MTIT, called (XROAD Or UXP), as a solution to the problem of exchanging data between the different health information systems used by healthcare institutions in Palestine. The research aims to provide a secure system for sharing the electronic health record according to the capabilities available to the Palestinian government and to maintain the security and privacy of patient's data, the proposed framework supports the decentralized environment while maintaining centralized control via MTIT, and if it is implemented, we do not need to change or replace the systems currently available in the various institutions. In this chapter, the researcher highlights the proposed framework.

6.2 XROAD/UXP suggested Workflow for healthcare institutions in Palestine

Figure 6.1 shows the framework for interoperability between the various health care institutions in Palestine according to the following working mechanism based on the framework architecture proposed in Figure 6.1:

- The service consumer enters the necessary service information through a SOAP or RESET message.

- The message is pay loaded to the encrypted channel through the consumer security server, which encrypts the message entered.
- The signatures and certificates used in the message are verified by the central server that passes the message to the service provider or rejects it.
- The service provider's security server receives the message, verifies its authenticity, and then passes it to an adapter server. The adapter server converts the message into a format that the service provider's internal system can use.
- The adapter server accesses the database of the service provider and then inquiries about the required data.
- The service provider encapsulates data through a SOAP or RESET message.
- The message is pay loaded to the encrypted channel through the provider security server, which encrypts the message entered.
- The signatures and certificates used in the message are verified by the central server that passes the message to the service consumer or rejects it.
- The service consumer security server receives the message, verifies its authenticity, and then reads the message and uses it.

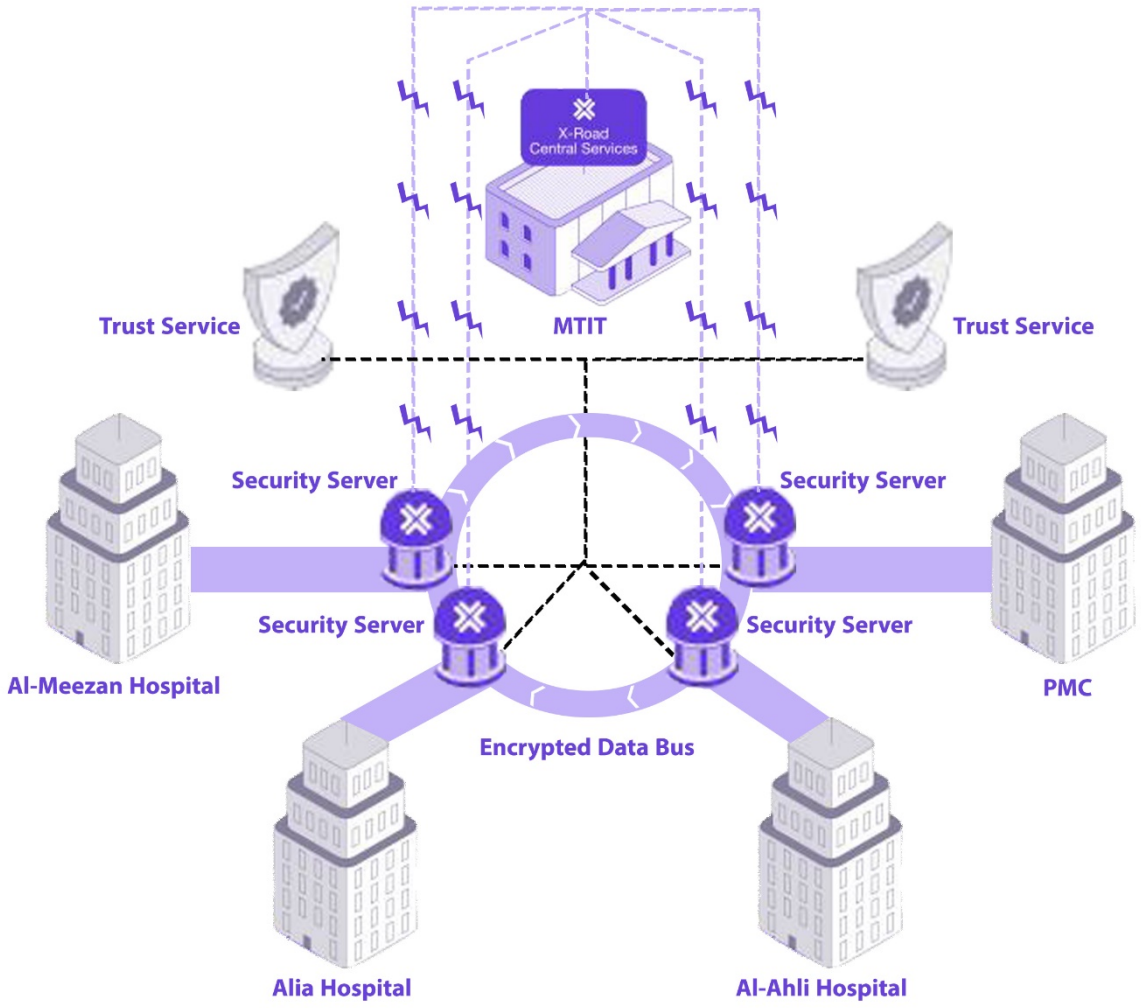

Figure 6.1: Framework Architecture

6.3 Practical Interoperability Framework

This section presents the prototype of the practical framework for interoperability between health care institutions, as it shows how the electronic health record is requested by a data consumer (health institution) and the response to this request by the data provider (health

care institution) and then displays the electronic health record. It also shows how the data is searched, The JSON format of response data, as well as data processing and display.

6.4 Interoperability Data Flow

Figure 6.2 shows the data flow of our proposed framework, from the moment the data is requested (Entering the ID number) by the consumer, the request is encrypted by the consumer security server, then ensures that the login with certificate and authentication are available and then loaded to the encrypted data bus to transfer the encrypted data to the service provider security server, the security server then decrypts the request and passes it to an adapter/connector server that queries the results through the database server and then returns the result (Electronic health record) as JSON/XML message to the service consumer, in the same previous sequence, after that the consumer will convert data as JSON/XML message to information can be read by healthcare employees (physicians, and others).

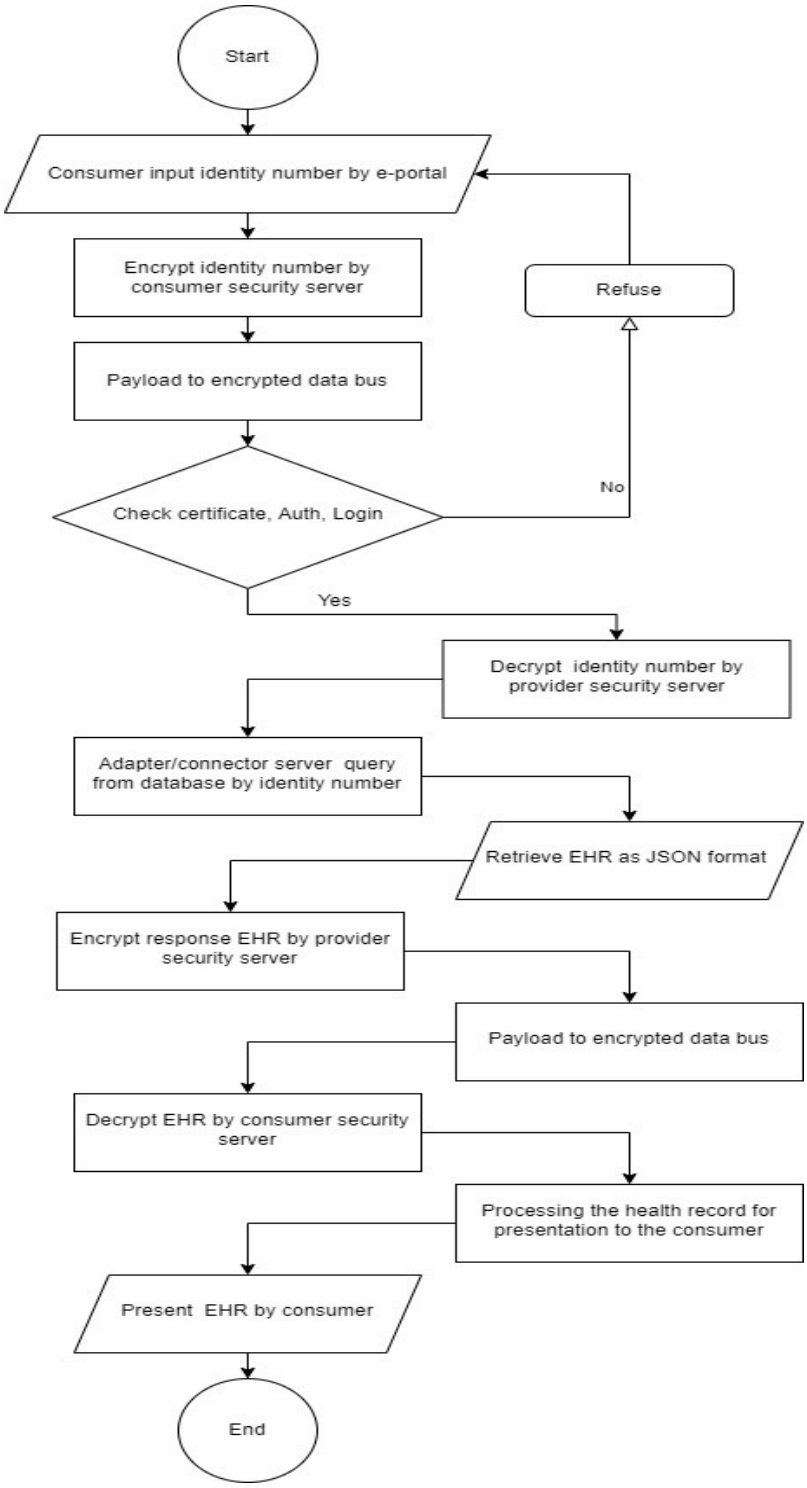

Figure 6.2: interoperability Data Flow

6.5 Prototype

A prototype for interoperability between two health institutions, the first, Al-Ahli Hospital, and the second, Istishari Arab Hospital. The prototype provided the creation of an electronic health record in health institutions and the ability to query, add and modify it, in addition to controlling the exchanged data. The prototype supports the exchange of electronic health records as a JSON message and then reading and displaying them to users of healthcare systems with an ideal display. When searching for the electronic health record through the identification number, the system displays all EHRs available to the patient from the two institutions.

6.6 Consumer/Provider patient EHR.

EHR consumer is the health institution that requests data from various health care institutions. An EHR provider is the institution that supplies the electronic health record to the institution that requests it.

Figure 6.3 presents the patient electronic health record management system, previously defined by different health institutions, whether they are service providers or consumers, represented by the health information system.

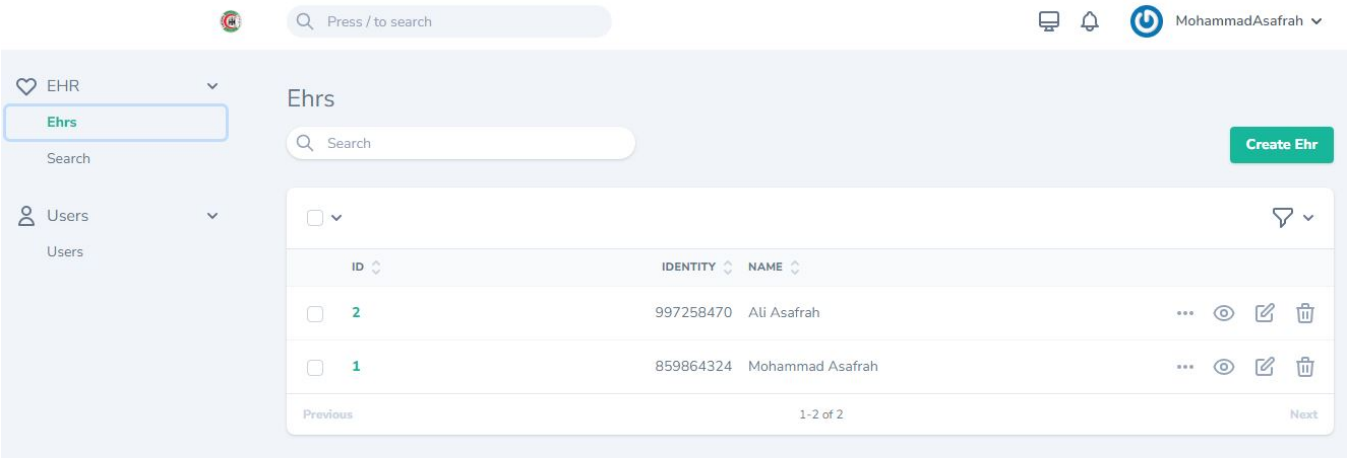

Figure 6.3: Consumer/Provider internal medical records

6.7 Search for a patient's EHR.

The search screen contains information (such as the identity number) that the service consumer sends to the service provider, which is the data that is understood by both parties. The service provider inquiries about the electronic health record in the database and return the results (EHR) to the service consumer

Figure 6.4 displays the search screen for electronic health records via the interoperability system, by entering the personal identification number. After entering the identification number and pressing the search button, the system automatically collects data from all medical centers providing the service in the form of JSON/XML, the data is then presented in tables distributed according to specific permissions after the consent of the patient.

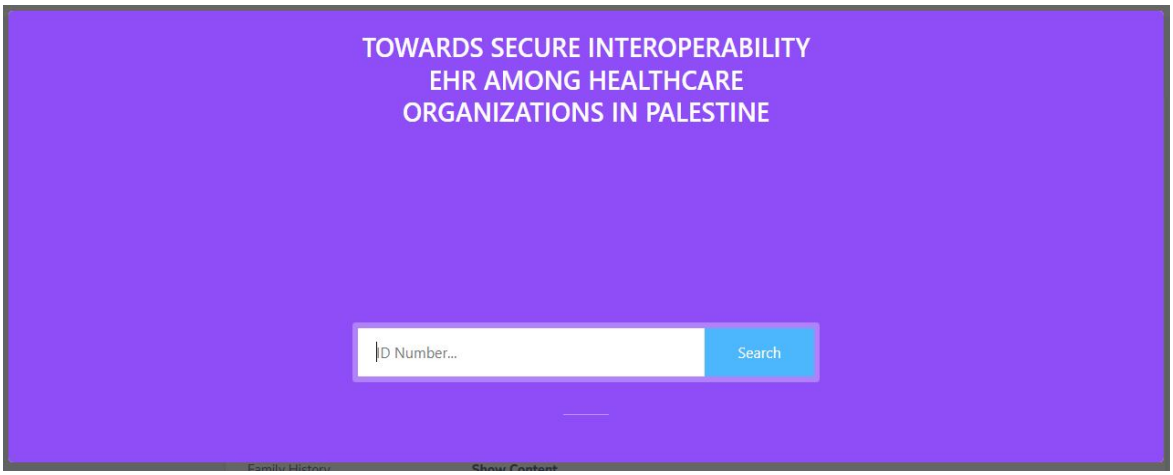

Figure 6.4: Search for electronic health records.

6.8 JSON data from the service provider

Figure 6.5 shows the data being requested from the service provider, where the message is pay loaded as JSON data, and passed through the XROAD system until it is read and viewed by the service consumer.

```
[
  {
    "id": 1,
    "identity": 859864324,
    "name": "Mohammad Asafrah",
    "age": "29",
    "gender": "Male",
    "diagnoses": "wdfq",
    "problem_list": "ef",
    "allergies": "erw",
    "family_history": "werf",
    "immunization": "wef",
    "medications": "ew",
    "procedures": "wef",
    "lab_orders": "we",
    "vital_signs": "wref",
    "reports": "we",
    "utilization": "wf",
    "free_text": "efw",
    "form_date": "2022-05-30 00:00:00",
    "created_at": "2022-05-30 06:17:29",
    "updated_at": "2022-05-30 06:17:29",
    "deleted_at": null
  }
]
```


Figure 6.5: JSON data from the service provider

6.9 View HER's, search results

Figure 6.6 displays the various medical records collected from different healthcare centers through the interoperability system, the example displays the electronic health records of Al-Ahli Hospital and the Palestinian Medical Complex (PMC).

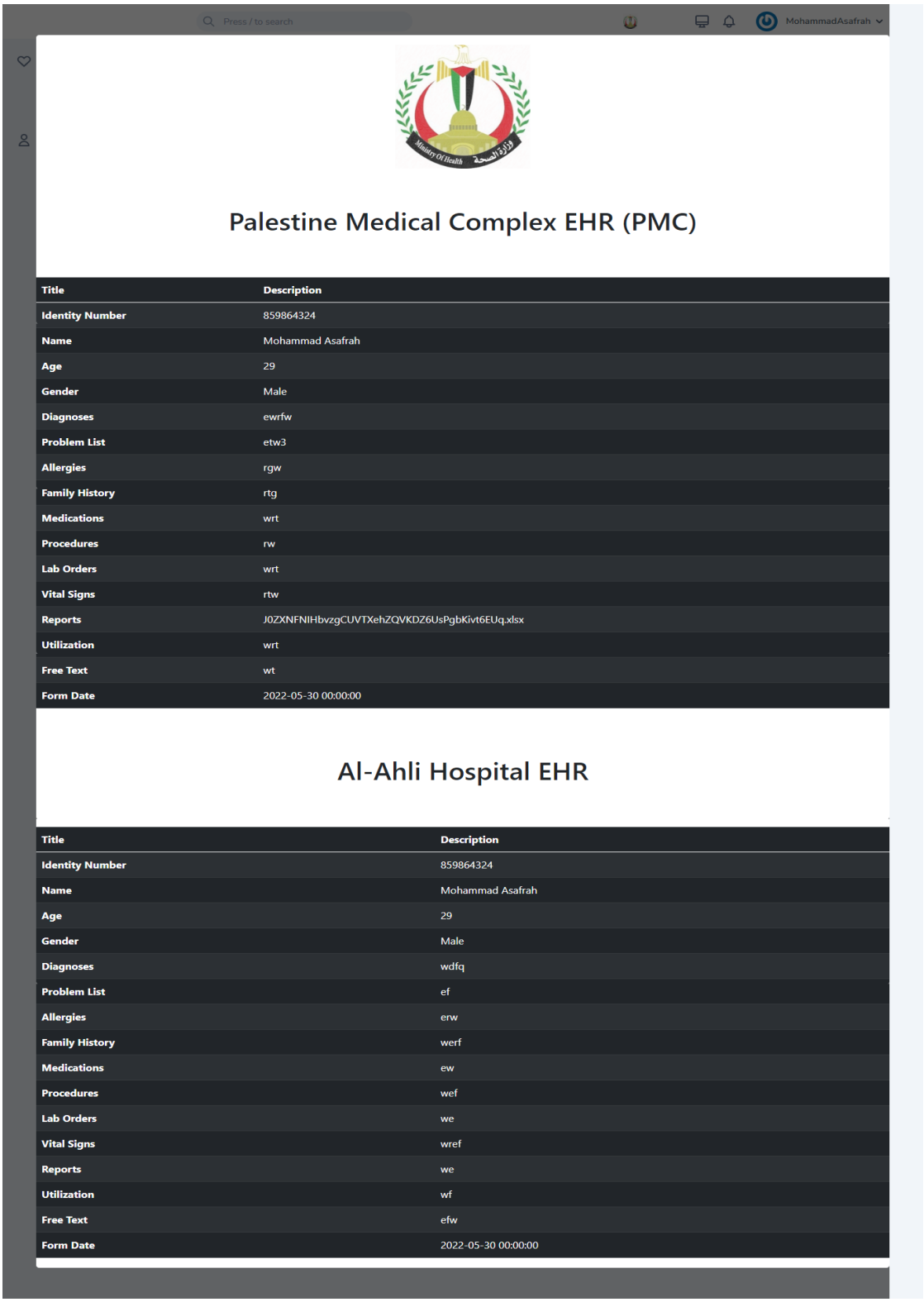

Figure 6.6: Medical records, search results

Chapter 7: DISCUSSION AND IMPLICATIONS

7.1 Overview

This chapter presents the author's discussion of the different challenges and benefits of adopting interoperability among Palestinian healthcare institutions and discusses the proposed framework for achieving secure interoperability between private and public healthcare centers in Palestine.

7.2 Discussion

The focus of the research was on pinpointing the benefits and challenges of interoperability and how private and public health institutions in Palestine can achieve this securely by providing an appropriate interoperability framework. According to the results, interoperability is very important between private and public health care centers in Palestine. At the moment there is no possibility of interoperability, and patients have to take a paper form of medical information from the hospital to other medical centers for the continuity of health care, furthermore, there are a lot of challenges that face applying interoperability in Palestine as was found by our analysis and the literature review.

Interoperability challenges

Different health institutions face many challenges in interoperability as mentioned in the literature, and in Palestine, a lot of efforts must be made to focus on the challenges facing the existence of a secure and appropriate environment for interoperability, so it is necessary to solve all these challenges to make interoperability between the different health care centers. According to the results, one of the important challenges for interoperability, which must be focused more on, is the lack of policies and laws in Palestine that support interoperability, and then achieve information security and privacy. The second major challenge was the lack

of an updated infrastructure at the Palestinian Ministry of Health and private health institutions to achieve interoperability. The survey revealed that the distribution of authorizations and auditing requests on the system as well as maintaining the security and privacy of information were the next challenge. Implementing interoperability with different applications and software used by different health care institutions, and the cost. These were the last two challenges.

From the researcher's point of view, if the necessary policies and laws to protect interoperability are available by the Palestinian Council of Ministers, and the Palestinian Ministry of Telecommunications and Information Technology adopts it through the owned interoperability system, which is called (XROAD), most health institutions will look at the policies, laws and the implementing agency for interoperability with great importance to increase confidence and take appropriate decisions by decision makers in these institutions. Besides, at the internal level of health institutions, the systems must be integrated, and the data entered should be accurate, and this leads to the desired result, which is the great benefit of sharing clinical and medical information between private and public health care centers in Palestine. It is also very important to use international standards in interoperability and information security to overcome critical problems in interoperability.

Many studies agreed on the importance of standards in interoperability, including the study (Olaronke, Abimbola, Ishaya, and Janet), which considered privacy and security policies as an essential part of designing an interoperable system. Healthcare Policies must be widely agreed upon by patients and practitioners on the terms and conditions for access to and dissemination of patient data. Adequate protection of health information privacy must also be considered in the development of an interoperability healthcare system. Legislation and

regulation should be frequently considered by reevaluating emerging technologies and capabilities. Also, authentication technologies such as passwords and biometrics (Olaronke et al., 2013).

(Dimitrios & Angelina) reported that policies are roadmaps for interoperability in Europe and abroad, where appropriate guidance at all levels of the healthcare ecosystem helps to drive all actors towards actions that are in line with the holistic vision of citizen-centered healthcare (Kouroubali & Katehakis, 2019).

Interoperability is beneficial to all stakeholders including patients, medical centers, and clinicians, according to the literature and findings, the patient's clinical information must be obtained and shared.

The results show that interoperability standards, the most important of which is the HL7 standard in addition to the clinical document structure, can be useful in transferring a medical document into digital format, and most importantly that the ICT platform should support the sharing of this information to different health care centers. According to the researcher's point of view, if the electronic health record is developed in a digital format, then we need a secure electronic system to transfer data from one place to another. The framework proposed by the researcher is considered one of the most important and best frameworks used for interoperability in the world, represented by the (XROAD) system owned by the Palestinian Ministry of Telecommunications and Information Technology. Besides, the framework will be decentralized in a way that it allows different systems to apply their local security policies, at the same time it is centrally controlled by MTIT which will support the trust of the framework and guarantee the application of the policies and regulations.

In Palestine, different health centers use different systems and different databases, so the centralized system cannot be applied to Palestine. One of the disadvantages of the central system is that if part of it stops working, the whole system stops. As for the decentralized approach, it can be the best solution for interoperability in Palestine, Peer to Peer is useful to support the exchange of a patient's electronic health record, and according to the results of questionnaires and interviews, medical and clinical information should be exchanged reliably and securely.

Interoperability contributes to reducing the time for obtaining the electronic health record by other institutions, as the time for obtaining information according to the results was between one hour and 24 hours in the majority, and this time is relatively large in health and has negative effects on the patient's health and the quality of health care services.

Interoperability Benefits

Benefits mentioned by some studies is to reduce the time in obtaining medical information, where the research (William and Christian), declared that interoperability has many benefits, the most important of which is improving operational efficiency and reducing the time in obtaining the patient's health record (Gordon & Catalini, 2018).

According to the results, interoperability improves the quality of health care and reduces medical errors, repetition of lab tests and medical images that could endanger the patient's life, in addition to reducing the cost of treatment for the patient, sharing information between medical staff in various health institutions and exchanging different experiences, and helps to avoid filling out multiple forms, while improving decision-making and developing work in various medical centers.

(Robi) study shows many successful health interoperability cases, and these health organizations have benefited from reducing potential errors, avoiding costly redundancies, and saving time in healthcare (Robi, 2021).

Another study evaluated the benefits of interoperability between health care organizations in America that significantly improved health outcomes for Americans, the most important of which are lower health care costs, improved health care quality, improved patient safety, and improved population health.[5]

Proposed framework for interoperability

The proposed framework provides the necessary solutions to many of the interoperability challenges in Palestine, which are information security, patient privacy, decentralization, and the necessary standards for interoperability, in addition to authentication and auditing. The framework offers many benefits at the level of patients, institutions, and health service providers, where the framework works to provide medical services on time, reduces the duplication of examinations and medical images, reduces the cost of treatment, and contributes to reducing medical errors leading to more accurate diagnosis for patients, improving decision-making, and exchanging experiences between Health care workers, and all of the above leads to an increase in the quality of health care in Palestine.

The researcher proposed a framework for interoperability through the Palestinian Ministry of Telecommunications and Information Technology, and this framework is considered the best and most widely used in the world by governments, as it is used for interoperability

[5] FACT SHEET: HEALTH IT INTEROPERABILITY: https://www.ehidc.org/sites/default/files/resources/files/2013-08-26_-_eHI_-_HIT_Interoperability_-_Fact_Sheet_0.pdf.

between ministries and government institutions in Palestine since 2011. It is very secure and easy to apply, as the researcher has 4 years of experience working on this system, meaning that he can apply the framework at any time he obtains approval and support from the Palestinian government.

7.3 Conclusions

The research aims to study the secure interoperability between private and public health care centers in Palestine. This research is based on a literature review, interviews with information technology officials, and questionnaires on health workers in the hospitals in Palestine, including Al-Ahli Hospital, The governmental hospital of Hebron (Alia), and Al-Meezan hospital, Palestine medical complex (PMC) and Istishari Arab hospital. With the help of questionnaire and interview results, we have presented some critical challenges in adopting interoperability, some of which have a high level of importance and should be focused on and include policies and laws regulating interoperability, in addition to standards for e-health, integration, information security, privacy, cost, infrastructure. In the scenario in which there is no possibility of interoperability between private and public healthcare centers in Palestine so far, the focus must be on policies and laws and then focus on implementing appropriate standards and selecting the appropriate ICT platform for use. The results show that 90% of interoperability depends on standards, IT tools, and communications, some private health centers and public centers represented by the Palestinian Ministry of Health do not have the possibility of interoperability, at the moment they need to develop the infrastructure and provide the basic requirements for interoperability in Palestine.

Patients need clinical information such as discharge summaries, different medical records or hospital reports, and results of lab tests, health images, etc., when they move from one health

center to another, for the continuity of health care services. Clinical information and the electronic health record must be in the form of a digital document that can be developed through electronic health standards. But to exchange the electronic health record between different health centers we need an electronic communication framework that hospitals can share.

Interview and questionnaire answers show that if there is interoperability, then access to information should be with the consent of the patient and the person authorized only to provide privacy and information security for patients. After analyzing all the research studies, there is a need to focus on:

- Policies and laws regulating interoperability,
- e-health standards
- Information and communication technology
- Access to information in a secure manner.

7.4 Final Findings

- Healthcare staff in private and public health centers in Palestine determined that the implementation of secure interoperability in Palestine faces major challenges that limit the possibility of interoperability at present, as the statistical average was (3.52) 70.38%.

  Figure 7.1 shows each field percentage as follows:

  a. Interfacing 70.6%
  b. Integration of different applications 73.4%
  c. Privacy of information 74%

d. Authentication and auditing 75.2%

e. The implementation cost of an interoperable system is 72.4%

f. Security of shareable information 71.2%

g. Absence of infrastructure for information exchange 68.8%

h. Absence of trust in outside information 66.8%

i. The hospital has strict policies regarding information sharing 69.6%

j. Resistance to use of a new computer-based system by staff members 61.8%

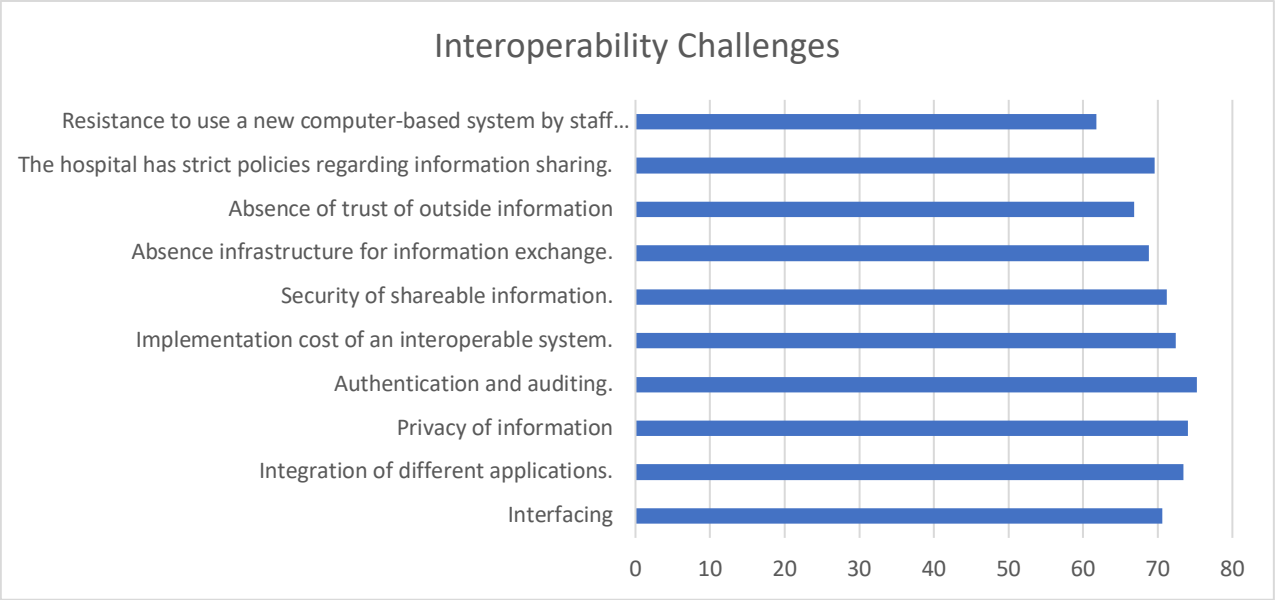

Figure 7.1: Interoperability Challenges from the viewpoint of healthcare staff.

- Healthcare staff and public health centers in Palestine determined that implementing secure interoperability in Palestine has great benefits that encourage the possibility of interoperability in Palestine, where the statistical average was (3.74) 74.79%. Figure 7.2 shows each field percentage as follows:

  a. The overall cost of the patient's treatment will be reduced by 69.6%

b. The quality of patient care will be improved by 73.6%

c. Safety of patient care will be better guaranteed at 75.6%

d. Interoperability will help to generate a more accurate diagnosis of 74.6%

e. Interoperability will help to reduce duplication of lab and imaging tests by 77.6%

f. Interoperability will help in preventing drug-drug interactions 75.4%

g. Interoperability will reduce time in patient sessions by 70.6%

h. Interoperability will help improve decision making 73.6%

i. Interoperability will help avoid filling multiple forms 77.2%

j. Interoperability will help reduce health care costs by 73.4%

k. Interoperability will improve the reputation of hospitals and clinics by 75.4%

l. Sharing experiences and knowledge between healthcare staff 76.4%

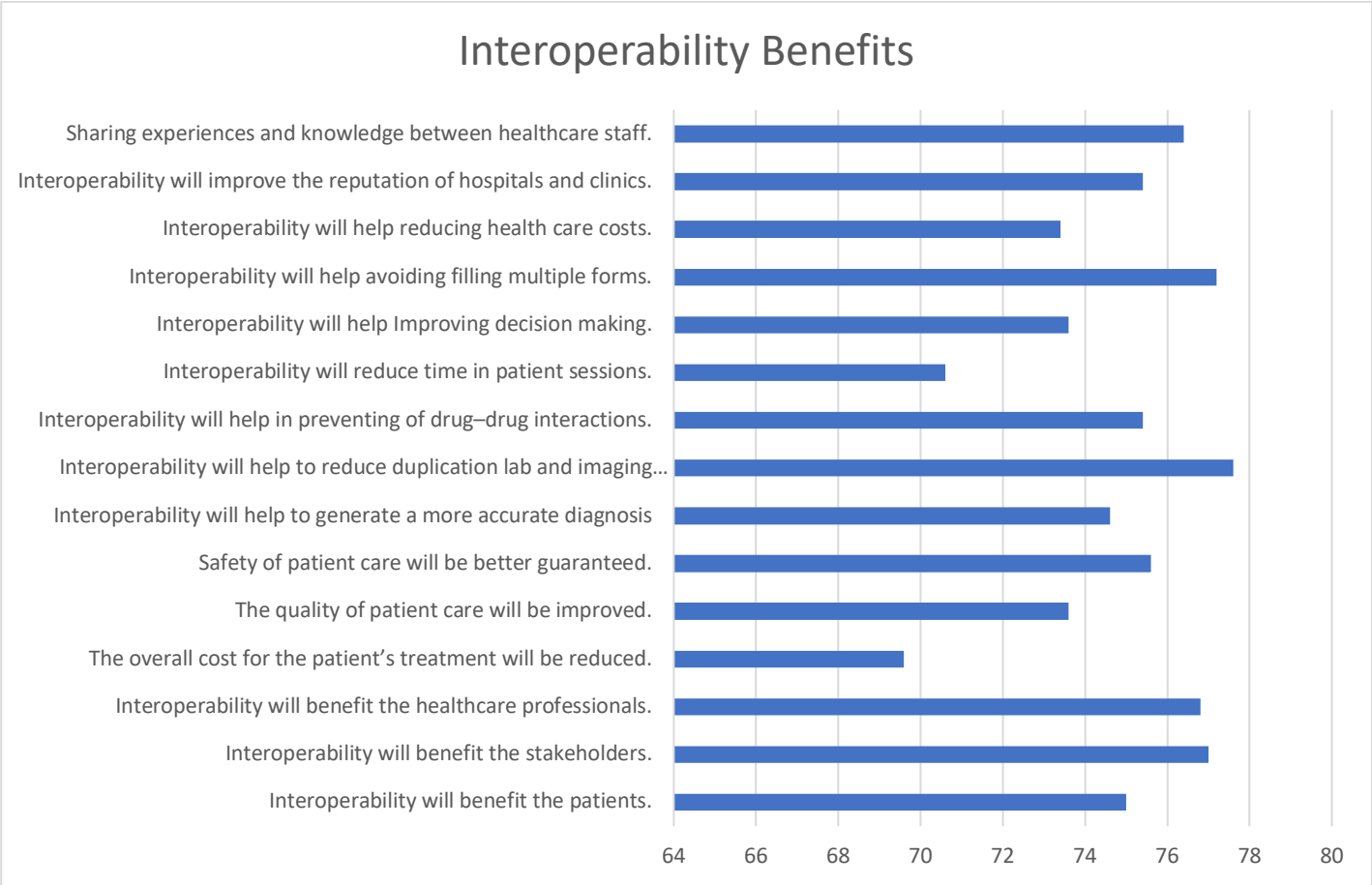

Figure 7.2: Interoperability Benefits from the viewpoint of healthcare staff.

- Healthcare staff in private and public health centers in Palestine determined patient information requirements for interoperability in Palestine, where the statistical average was (3.75) 75.06%.

  Figure 7.3 shows each field percentage as follows:

  a. Medical history 76.2%

  b. Vital signs 74.8 %

  c. Medication list 77.2%

d. Allergy list 79%

e. Laboratory results in 78.2%

f. Diagnostic imaging results 77.2%

g. Discharge instructions/ notes 74.6%

h. Implanted medical devices list 74.2%

i. Full health record (HR) information 71%

j. Personal information 70.4%

k. Patient's medical diagnoses 74.6%

l. Referral services 73.6%

m. Family history 74.8%

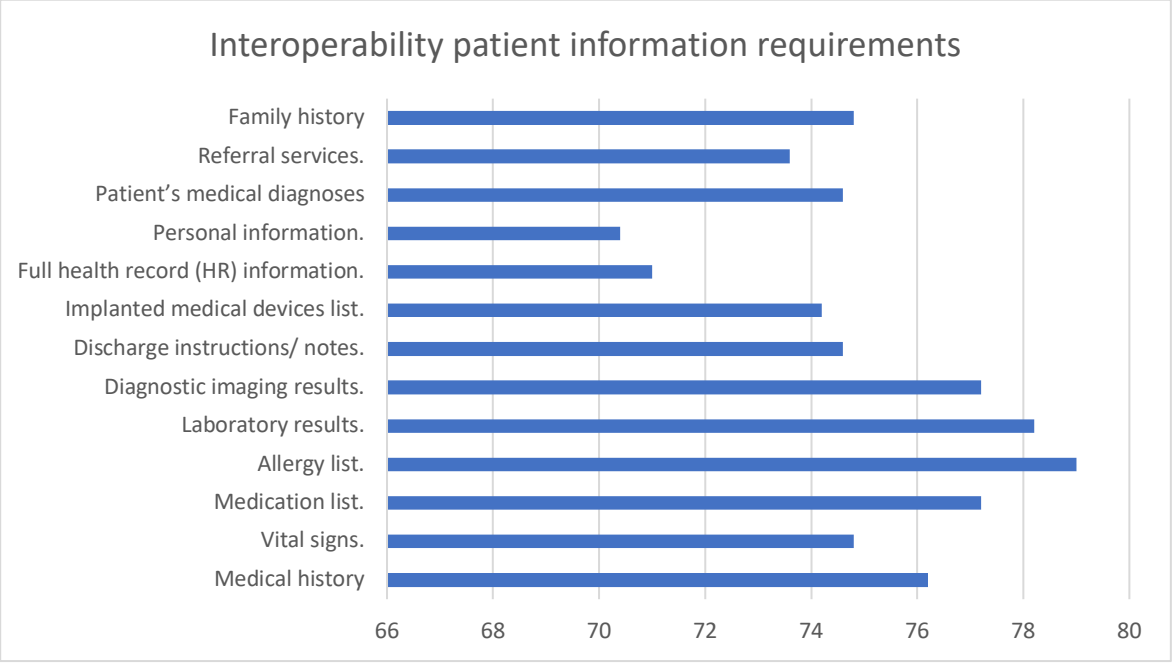

Figure 7.3: Interoperability of patient information requirements from the viewpoint of healthcare staff.

- Healthcare staff in private and public health centers in Palestine identified the technical requirements for interoperability in Palestine, where the statistical average was (3.9) 78.08%.

  Figure 7.4 shows each field percentage as follows:

  a. Using the necessary hardware, and equipment to maintain the confidentiality of information interoperability 78%
  b. Using the necessary software to maintain the confidentiality of information interoperability 80.2%
  c. The need for dedicated computers & tablets to be used in interoperable systems is 77%
  d. Need software programs for better use of interoperability 79.8%
  e. Need mobile applications for better utility of interoperability 75.8%
  f. The need for dedicated internet connection for users of interoperable systems is 78.4%
  g. Need for dedicated information technology staff for troubleshooting 81%
  h. Need training for healthcare professionals to use the system 81%
  i. Need the establishment of a help desk to follow up on system problems and take the appropriate action 79.4%

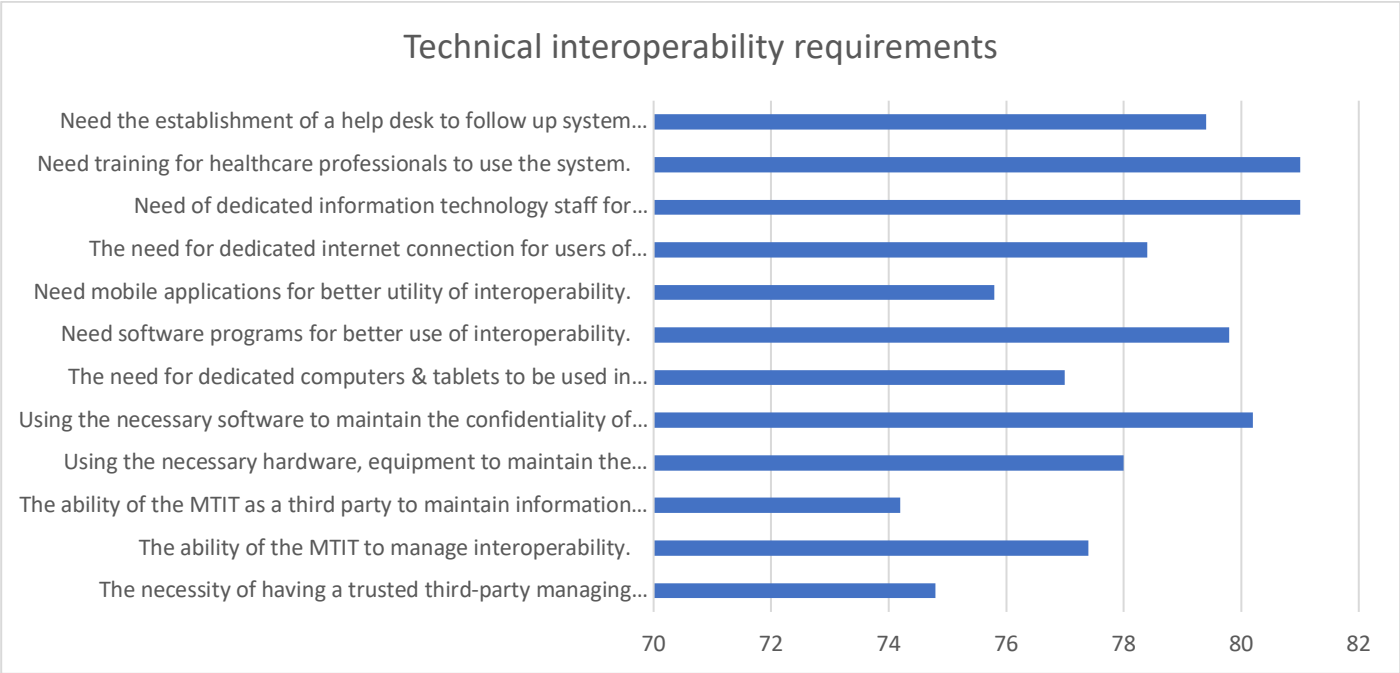

Figure 7.4: Technical interoperability requirements from the viewpoint of healthcare staff.

7.5 Recommendations

According to the research study, the researcher has some recommendations for experts in the area of e-health and those responsible for electronic systems in private and public health centers, and for decision-makers in the State of Palestine, these recommendations will help in achieving interoperability between health care institutions in Palestine, knowing that health care institutions in the public sector and the private are not interoperable yet. The results of the interviews with e-health specialists and the analysis of the questionnaire supported the researcher to provide some useful recommendations for interoperability in private and public health care institutions in Palestine.

- ✓ The Palestinian government should work on setting policies and laws for regulating interoperability, the security of health information, and the preservation of patients' privacy. This task can be done in collaboration among healthcare institutions, the

ministry of health, and the ministry of telecommunication by establishing a group of experts who will be responsible to study the situation of similar policies and adopt suitable policies that fit well our Palestinian institutions and community. There are many established and well-known international standards that might help create such policies.

- ✓ Healthcare centers in the public sector represented by the Palestinian Ministry of Health and the private sector must adopt e-health standards such as HL7 so that the HL7 V3 standard and CDA can be used to develop a digital document for the electronic health record using the health center database. Some of these institutions have partially used some of these standards. And to completely follow these standards, the ministry of health should first determine the required standards to be followed and then train a group of people on how to apply these standards. These people will then follow up with hospitals step by step with the aim of full deployment of these standards. The ministry of health should make sure that all health institutions are using these unified standards.
- ✓ Since the healthcare systems in healthcare centers in Palestine are decentralized in nature, there is a need for an ICT infrastructure to exchange electronic health records between private and public healthcare centers. Therefore, a distributed peer-to-peer environment can be beneficial. Peer-to-peer communication would provide an environment in which more healthcare centers can join at any time. One solution is to use the peer-to-peer approach provided by the system (UXP, XROAD) which will provide privacy because the communication will be one-to-one using a data transporter that encrypts and protects the data with the best and latest security

systems. A major advantage of using this framework is that it is already established and used by MTIT in Palestine since 2011 to obtain interoperability between different Palestinian governmental organizations. UXP supports transport protocols in Palestine and data encryption and supports XML and JSON data format, to share data through it, is the.

- ✓ To provide a better user interface, electronic health records can be viewed through the browser application or customized application that supports it.
- ✓ Because there are many healthcare professionals with different scientific fields of specialization and different ranks, access to data must be controlled, and their roles appropriately defined to control the issue of accessibility. This can be achieved by adding the electronic health record resulting from interoperability to the electronic government portal in the Ministry of Telecommunications and Information Technology so that it is one of the important services provided by the Palestinian government to citizens.
- ✓ The framework is a new system, which requires sufficient workshops and training for the medical team working on this system, in addition to the presence of a technical support team to solve problems as they occur.
- ✓ Internal and external budgets and funding are needed to develop the framework and create the infrastructure in the various health institutions necessary for interoperability.

7.6 Directions for Future Work

This research study focused on secure interoperability between private and public healthcare organizations in Palestine. The researcher made great efforts to obtain an implementable

method in Palestine that would enable healthcare organizations to obtain interoperability and exchange health information. The researcher believes that the presented framework will be useful for professionals who are thinking about achieving interoperability, the researcher has conducted a comprehensive analysis of the interviews and the results of the questionnaire, but there is a possibility of missing important aspects that the researcher did not address, in the future there is a need to focus on the architecture of a distributed peer-to-peer system between different healthcare organizations represented by the XROAD/UXP system that The researcher suggested, as the best way for interoperability in Palestine, and to collect the requirements and needs of implementing the real system. Also, a comparative study can be done to find out the benefits and challenges of interoperability between private and public health care institutions in Palestine using the information and communication technology platform with those presented in this thesis, in addition to presenting this research and its results to the Palestinian Council of Ministers, the Ministry of Telecommunications and Information Technology, and the Ministry of Health, to adopt it and start the necessary procedures to implement it in real life, because of its great benefit to all citizens of the State of Palestine.

There are other global frameworks for interoperability such as the blockchain that can be relied upon or studied, but the researcher believes that the framework presented by the researcher has greater strengths for its implementation in Palestine, future studies can also be done to compare these frameworks and the possibility of their application in Palestine.

Future studies propose semantic interoperability solutions in terms of heterogeneity in the exchanged data between different systems, address their implications, extract information

from them electronically, propose appropriate solutions, and support this through policies and laws that help achieve homogeneity in exchanged data.

7.7 Challenges and Limitations

The researcher faced many challenges during the study conduction:

1. Differences in the language of the study with the preferred language of the respondents forced the researcher to translate and distribute the Arabic version of the questionnaire.
2. The workload of health sector workers, and the lack of responses by filling out questionnaires and conducting interviews.
3. Difficulty in moving between governorates to collect questionnaires and conduct interviews.
4. Decision makers in all hospitals of the study sample refused to conduct interviews on the pretext that they did not have time.
5. E-Health officials at Istishari Arab Hospital declined to conduct interviews.
6. Procedures for consent to collect information.

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APPENDICES

Appendix A: Arbitrators Table

No	Name	Place of work
1	Dr.Belal Amro	Hebron University
2	Dr.Yousef Memi	American Arab University
3	Dr. Ibrahim Ahmaro	Hebron University
4	Dr.Mohammad Khleif	American Arab University
5	Dr.Ali El-Khateeb	University College of Applied Sciences - Gaza
6	Dr.Wasim Idris Mustafa	Palestine Polytechnic University

Appendix B: Health Technologists in Hospitals Table

No	Name	Place of work
1	Marwan Shehadeh	Al-Ahli Hospital
2	Mohammed Al Mohtaseb	Al-Meezan hospital
3	Ibrahim Al-Hasanat	The governmental hospital of Hebron (Alia)
4	Mohamed Salah El Din	Palestine medical complex (PMC)

Appendix C: Health worker's Questionnaire

- **Arabic Health workers questionnaire**

نحو ربط بيني آمن للسجلات الصحية الالكترونية بين مؤسسات الرعاية الصحية في فلسطين

أنا الباحث محمد العصافرة طالب ماجستير تخصص المعلوماتية الصحية، في الجامعة العربية الأمريكية - رام الله، أقوم ببحث علمي للتحقيق في الوضع الحالي لأنظمة السجلات الصحية الإلكترونية في فلسطين واقتراح نموذج التشغيل البيني بين مراكز الرعاية الصحة الخاصة والعامة في فلسطين. كجزء من هذا البحث، أقوم بإجراء مسح لاستكشاف ظروف التشغيل البيني والعقبات والفوائد والمتطلبات من منظور العاملين في الرعاية الصحية يستهدف هذا الاستبيان الأطباء والعاملين في مجال الرعاية الصحية (مثل الممرضين وأخصائيين الأشعة وغيرهم) الذين يعملون في مستشفيات مختلفة في فلسطين، يتم تضمين فقط المستشفيات التي لديها أنظمة السجلات الصحية الإلكترونية (EHR). لدينا ثقة كبيرة بكم وبحرصكم على دعم البحث العلمي، لذا نرجو منكم ملء الاستبيان المرفق. ستكون البيانات المجمعة مركزية ومهمة لنجاح هذا البحث، لذا يرجى الإجابة بدقة على الفقرات الموضحة في الصفحات المرفقة. سيتم التعامل مع إجاباتك بسرية تامة ولأغراض البحث العلمي فقط.

***الشروط الاساسية

السجل الصحي الإلكتروني (EHR) هو مستودع للمعلومات المتعلقة بالحالة الصحية للمريض، في شكل قابل للمعالجة بواسطة الكمبيوتر.

قابلية التشغيل البيني هي قدرة أنظمة المعلومات المختلفة على الوصول إلى البيانات وتبادلها ودمجها واستخدامها بطريقة منسقة.

المستوى الصحي السابع (HL7) عبارة عن مجموعة من المعايير الدولية المستخدمة لتقديم التوجيه بشأن نقل البيانات ومشاركتها بين مختلف مقدمي الرعاية الصحية.

تكنولوجيا المعلومات والاتصالات، أو تكنولوجيا المعلومات والاتصالات (أو التقنيات)، هي البنية التحتية والمكونات التي تمكن الحوسبة الحديثة.

(MTIT)وزارة الاتصالات وتكنولوجيا المعلومات.

(HIS) نظام المعلومات الصحية.

بنية المستندات السريرية (CDA) هي معيار ترميز مرن وشائع تم تطويره بواسطة Health Level 7 International (HL7)التي تحدد بنية بعض السجلات الطبية، مثل ملخصات التفريغ وملاحظات التقدم، كطريقة لتبادل هذه المعلومات بشكل أفضل بين مقدمي الخدمات والمرضى.

❖ **الجزء الأول: المعلومات الديموغرافية**

1. **الجنس**
   a. **ذكر**
   b. **أنثى**
2. **العمر _____**
3. **التخصص الطبي**
   a. **طبيب**
   b. **ممرضة**
   c. **الطبيب المقيم**
   d. **صيدلاني**
   e. **فني مختبر**
   f. **طبيب تخدير**
   g. **قابلة**
   h. **أخصائي العلاج الوظيفي**
   i. **بصريات**
   j. **معالج فيزيائي**
   k. **معالج إشعاعي**
   l. **آخر: _____**
4. **مكان عملك الحالي**
   a. **مستشفى الاهلي**
   b. **مستشفى الخليل الحكومي (علياء)**

c. مستشفى جمعية الهلال الاحمر الفلسطيني

d. مستشفى الميزان

e. مجمع فلسطين الطبي (PMC)

f. المستشفى الاستشاري العربي

g. آخر: _____

5. عدد سنوات الخبرة (بعد التوظيف)

a. 4-1

b. 8-5

c. 12-9

d. 12 <

6. عدد سنوات استخدام نظام HIS في عملك.

a. 1>

b. 4-1

c. 8-5

d. 8 <

7. القسم الذي تعمل فيه.

a. قسم حديثي الولادة

b. قسم الحروق

c. قسم خدمات التعقيم المركزي (CSSD)

d. خدمات المسنين

e. أمراض الجهاز الهضمي

f. السيطرة على العدوى

g. أمراض الدم

h. فحص الثدي

i. الطب الباطني

j. طب الأطفال

k. الجراحة العامة

l. القلب والأوعية الدموية

m. أمراض النساء والولادة

n. التوليد

o. علم الأمراض

p. طب الكلى

q. تَغذِيَة

r. الصيدلية

s. طب العظام

t. العلاج الطبيعي

u. العلاج الإشعاعي

v. الأورام

w. علم الأعصاب

x. الطوارىء

y. الروماتيزم

z. الصحة الجنسية

aa. جراحة المسالك البولية

bb. وحدة العناية المركزة (ICU)

cc. وحدة العناية التاجية (CCU)

dd. الأشعة

ee. طب العيون

ff. طب الأنف والأذن والحنجرة

gg. علم الأعصاب

hh. الأشعة

ii. آخر: _____

❖ **الجزء الثاني: كيفية تبادل البيانات في المؤسسة التي تعمل بها.**

8. عادة ما يتم إرسال واستلام معلومات المرضى الخارجيين من مستشفيات أخرى في فلسطين باستخدام. (إجابة واحدة أو أكثر)؟

a. الأوراق

b. الفاكس

c. البريد الالكتروني

d. نظام الكمبيوتر

e. وسيلة تخزين محمولة

f. خدمات التخزين السحابية

g. آخر: _____

9. **الإطار الزمني المعتاد لتلقي معلومات السجلات الصحية الإلكترونية.**
   a. **خلال ساعة واحدة**
   b. **خلال 24 ساعة**
   c. **من 2 إلى 3 أيام**
   d. **أكثر من 3 أيام**
10. **أعتقد أن التشغيل البيني بين مراكز الرعاية الصحية الحكومية والمستشفيات الخاصة مفيد للمرضى والمهنيين وأصحاب المصلحة الآخرين في الرعاية الصحية؟**
   a. **نعم**
   b. **لا**
11. **أوافق على أن منصة تكنولوجيا المعلومات والاتصالات يمكن أن تلعب دورًا حيويًا في الحصول على إمكانية التشغيل البيني بين مراكز الرعاية الصحية العامة والخاصة والمستشفيات؟**
   a. **نعم**
   b. **لا**
   c. **لا أعلم**
12. **أعتقد أن الأنظمة المراد ربطها يجب أن تطبق المعايير مثل بنية المستندات السريرية (CDA) والمستوى الصحي 7 (HL7) ومعايير الخصوصية والأمن؟**
   a. **نعم**
   b. **لا**
   c. **لا أعلم**
13. **أوافق على أن تناسق البيانات المشتركة مهم أثناء التشغيل البيني؟**
   a. **نعم**

b. لا

c. لا أعلم

14. أوافق على أن الحكومة يجب أن تشارك بطريقة ما في عملية التشغيل البيني بين مؤسسات الرعاية الصحية؟

a. نعم

b. لا

c. لا أعلم

15. أعتقد أن أنظمة الصحة الإلكترونية هي بديل للأنظمة الورقية التقليدية؟

a. نعم

b. لا

c. لا أعلم

❖ **الجزء الثالث: تحديات التشغيل البيني**

برأيك ، أجب عن الأسئلة التالية عن طريق تحديد الحالة المناسبة لكل من تحديات التشغيل البيني المقترحة التالية؟

تحديات التشغيل البيني	اوافق بشدة	اوافق	محايد	أعارض	أعارض بشدة	لا أعلم
التواصل.						
ربط التطبيقات مختلفة.						
خصوصية المعلومات.						
المصادقة والتدقيق.						

تكلفة تنفيذ نظام قابل للتشغيل البيني.						
أمن المعلومات القابلة للمشاركة.						
نقص البنية التحتية لتبادل المعلومات.						
عدم الثقة في اخراج المعلومات من المؤسسة.						
لدى المستشفى سياسات صارمة فيما يتعلق بمشاركة المعلومات.						
مقاومة(رفض) استخدام نظام حاسوبي جديد من قبل الموظفين.						

❖ **الجزء الرابع: فوائد التشغيل البيني.**

برأيك ، أجب عن الأسئلة التالية عن طريق تحديد الحالة المناسبة لكل من مزايا التشغيل البيني المقترحة التالية؟

فوائد التشغيل البيني	اوافق بشدة	اوافق	محايد	أعارض	أعارض بشدة	لا أعلم
التشغيل البيني يعود بالفائدة على المرضى.						

التشغيل البيني يعود بالفائدة على مقدمي الرعاية الصحية.						
سيعود التشغيل البيني بالفائدة على المتخصصين في الرعاية الصحية.						
ستنخفض التكلفة الإجمالية لعلاج المريض.						
سوف تتحسن جودة رعاية المرضى						
سيتم ضمان سلامة رعاية المرضى بشكل أفضل.						
ستساعد إمكانية التشغيل البيني في إنشاء تشخيص أكثر دقة.						
ستساعد قابلية التشغيل البيني في الحد من تكرار الفحوصات والصور.						
ستساعد قابلية التشغيل البيني في منع التفاعلات الدوائية مع الأدوية.						
ستعمل إمكانية التشغيل البيني على تقليل الوقت في جلسات المريض.						

البيني في تحسين عملية صنع القرار.						
ستساعد إمكانية التشغيل البيني في تجنب ملء نماذج متعددة.						
ستساعد قابلية التشغيل البيني في تقليل تكاليف الرعاية الصحية.						
ستعمل إمكانية التشغيل البيني على تحسين سمعة المستشفيات والعيادات.						
تبادل الخبرات والمعرفة بين العاملين في مجال الرعاية الصحية.)						

❖ **الجزء الخامس: متطلبات التشغيل البيني**

✓ **القسم (أ): ما هي معلومات المريض التي تريد تبادلها إلكترونياً؟**

متطلبات التشغيل البيني	اوافق بشدة	اوافق	محايد	أعارض	أعارض بشدة	لا أعلم
السجل الطبي (التارخ الطبي)						
العلامات الحيوية						
قائمة العلاج						

قائمة الحساسية						
نتائج الفحوصات المخبرية						
نتائج تشخيص الصور الطبية						
تعليمات وملاحظات الخروج						
قائمة الأجهزة الطبية المستخدمة						
كل المعلومات في السجل الطبي						
المعلومات الشخصية						
خدمات التحويلات الطبية						
التاريخ المرضي للعائلة						

القسم (ب): متطلبات التشغيل البيني التقني: ما رأيك في ضرورة العناصر والخصائص التالية من أجل التطبيق الناجح لقابلية التشغيل البيني؟

متطلبات التشغيل البيني	اوافق بشدة	اوافق	محايد	أعارض	أعارض بشدة	لا أعلم
ضرورة وجود جهة خارجية موثوق بها لإدارة التشغيل البيني بين مؤسسات الرعاية الصحية.						

قدرة وزارة الاتصالات وتكنولوجيا المعلومات على إدارة التشغيل البيني.						
قدرة وزارة الاتصالات وتكنولوجيا المعلومات كطرف ثالث على الحفاظ على أمن المعلومات.						
استخدام الأجهزة والمعدات اللازمة للحفاظ على سرية إمكانية التشغيل البيني للمعلومات.						
ستخدام البرامج الضرورية للحفاظ على سرية إمكانية التشغيل البيني للمعلومات.						
الحاجة إلى أجهزة كمبيوتر وأجهزة لوحية مخصصة لاستخدامها في الأنظمة القابلة للتشغيل البيني.						
الحاجة إلى برامج تستخدم بشكل أفضل قابلية التشغيل البيني.						
الحاجة إلى تطبيقات هواتف ذكية						

تستخدم بشكل أفضل قابلية التشغيل البيني.						
الحاجة إلى اتصال إنترنت مخصص لمستخدمي الأنظمة القابلة للتشغيل البيني.						
الحاجة إلى موظفين متخصصين في تكنولوجيا المعلومات لاستكشاف الأخطاء وإصلاحها.						
الحاجة إلى تدريب المتخصصين في الرعاية الصحية على استخدام النظام.						
بحاجة إلى إنشاء مكتب مساعدة لمتابعة مشاكل النظام التي تحدث وتتخذ الإجراء المناسب.						

- **English Health Workers Questionnaire**

Towards Secure Interoperability EHR among Healthcare Organizations in Palestine

"نحو ربط بيني آمن للسجلات الصحية الالكترونية بين مؤسسات الرعاية الصحية في فلسطين"

I am the researcher, Mohammad Al-Asafra, a master's student in health informatics. At the Arab American University - Ramallah. I am researching to investigate the current state of the electronic health record systems available in Palestine and to propose an E-Health Interoperability framework to be achieved among healthcare institutions in Palestine. As part of this research, I am surveying to explore interoperability conditions, obstacles, and requirements from a clinician's perspective. This questionnaire targets doctors and health care workers (such as nurses, radiologists, etc.) who work in different hospitals in Palestine. Only hospitals with electronic health record (EHR) systems are included. We have great confidence in you and your keenness to support scientific research. So, we kindly ask you to fill out the attached questionnaire. The data collected will be central and important to the success of this research, so please answer accurately the paragraphs described on the attached pages. Your answers will be treated strictly confidentially and for scientific research purposes only.

***Key Terms

1. Electronic Health Record (EHR) is a repository of information regarding the health status of a subject of care, in computer processable form.

2. Interoperability is the ability of different information systems to access, exchange, integrate, and cooperatively use data in a coordinated manner.

3. Health Level Seven (HL7) is a set of international standards used to guide with transferring and sharing of data between various healthcare providers.

4. ICT, or information and communications technology (or technologies), is the infrastructure and components that enable modern computing.

5. MTIT (Ministry of Telecommunication & Information Technology).

6. HIS (Health Information System).

7. Clinical Document Architecture (CDA) is a popular, flexible markup standard developed by Health Level 7 International (HL7) that defines the structure of certain medical records, such as discharge summaries and progress notes, as a way to better exchange this information between providers and patients.

Part 1: Demographic Information

1. Gender
    a. Male
    b. Female
2. Age_____
3. Medical specialty
    a. Physician
    b. Nurse
    c. Resident physician
    d. Pharmacist
    e. Laboratory technician
    f. Anesthetist

g. Midwife

h. Occupational therapist

i. Orthoptist

j. Physical therapist

k. Radiation therapist

l. Other: _____

4. Place of your current work

a. Al-Ahli Hospital

b. The governmental hospital of Hebron (Alia)

c. Palestine red crescent society hospital

d. Al-Meezan hospital

e. Palestine medical complex (PMC)

f. Istishari Arab hospital

g. Other: _____

5. Years of experience (after being employed)

a. 1-4

b. 5-8

c. 9-12

d. >12

6. Years of using HIS system in your work

a. <1

b. 1-4

c. 5-8

d. >8

e. None

7. Department of your work
    a. Neonatal
    b. Burn
    c. Central sterile services department (CSSD)
    d. Elderly services
    e. Gastroenterology
    f. Infection control
    g. Hematology
    h. Breast screening
    i. Internal medicine
    j. Pediatrics
    k. General surgery
    l. Cardiovascular
    m. Obstetrics / Gynecology
    n. Maternity
    o. Pathology
    p. Nephrology
    q. Nutrition
    r. Pharmacy
    s. Orthopedics
    t. Physiotherapy
    u. Radiotherapy
    v. Oncology

w. Neurology

x. Emergency

y. Rheumatology

z. Sexual Health

aa. Urology

bb. Intensive care unit (ICU)

cc. Coronary care unit (CCU)

dd. Radiology

ee. Ophthalmology

ff. Otorhinolaryngology

gg. Neurology

hh. Radiology

ii. Other: _____

❖ **Part 2: Data Exchange Condition**

8. Outside patient information typically sent and received from other hospitals in Palestine using (one or more answers)?

a. Paper

b. Fax

c. Email

d. Computer system

e. Portable storage medium

f. Cloud storage services

g. Other: _____

9. The usual time frame for receiving EHR information.

   a. Within one hour

   b. Within 24 hours

   c. From 2 to 3 days

   d. More than 3 days

10. I think interoperability between government healthcare centers and private hospitals is beneficial for patients, professionals, and other healthcare stakeholders.

    a. Yes

    b. No

11. I agree that the information and communication technology (ICT) platform can play a vital role in obtaining interoperability between public and private healthcare centers and hospitals.

    a. Yes

    b. No

    c. I don't know

12. I think the systems to be linked should apply the standards such as clinical document architecture (CDA), health level 7 (HL7), and privacy and security Standards.

    a. Yes

b. No

c. I don't know

13. I agree that consistency of shared data is important during interoperability.

a. Yes

b. No

c. I don't know

I agree that the government should be somehow involved in the process of interoperability among healthcare institutions.

d. Yes

e. No

f. I don't know

14. I believe that health information systems are an alternative to traditional paper-based systems.

a. Yes

b. No

c. I don't know

❖ **Part 3: Interoperability Challenges**

In your opinion, answer the following questions by selecting the appropriate state for each of the following suggested interoperability challenges.

Interoperability Challenge	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**I don't know**

Interfacing.						
Integration of different applications.						
Privacy of information.						
Authentication and auditing.						
The implementation cost of an interoperable system.						
Security of shareable information.						
Absence of infrastructure for information exchange.						
Absence of trust in outside information**.**						
The hospital has strict policies regarding information sharing.						
Resistance to the use of a new computer-based system by staff members						

- **Part 4: Interoperability Benefits**

In your opinion, answer the following questions by selecting the appropriate state for each of the following suggested interoperability benefits.

Interoperability suggested benefits	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**I don't know**
Interoperability will benefit the patients.						
Interoperability will benefit the stakeholders.						
Interoperability will benefit healthcare professionals.						
The overall cost of the patient's treatment will be reduced.						
The quality of patient care will be improved.						
Safety of patient care will be better guaranteed.						
Interoperability will help to generate a more accurate diagnosis**.**						

Interoperability will help to reduce duplication of lab and imaging tests.						
Interoperability will help in preventing drug-drug interactions**.**						
Interoperability will reduce time in patient sessions.						
Interoperability will help Improve decision-making.						
Interoperability will help avoid filling multiple forms.						
Interoperability will help reduce health care costs.						
Interoperability will improve the reputation of hospitals and clinics.						
Sharing experiences and knowledge between healthcare staff.						

- **Part 5: Interoperability Requirements**
  - **Section A:** What patient information do you want to electronically exchange?

Question	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Medical history.					
Vital signs.					
Medication list.					
Allergy list.					
Laboratory results.					
Diagnostic imaging results.					
Discharge instructions/ notes.					
Implanted medical devices list.					
Full health record (HR) information.					
Personal information.					
Patient's medical diagnoses**.**					
Referral services.					
Family history.					

➢ **Section B: Technical Interoperability Requirements:** What is your opinion about the necessity of the following items and properties for the successful adoption of interoperability**?**

Item / property	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**I don't know**
The necessity of having trusted third-party managing interoperability between healthcare organizations.						
The ability of the MTIT to manage interoperability.						
The ability of the MTIT as a third party to maintain information security.						
Using the necessary hardware, and equipment to maintain the confidentiality of information interoperability.						
Using the necessary software to maintain the confidentiality of						

information interoperability.						
The need for dedicated computers & tablets to be used in interoperable systems**.**						
Need software programs for better use of interoperability.						
Need mobile applications for better utility of interoperability.						
The need for a dedicated internet connection for users of interoperable systems.						
Need for dedicated information technology staff for troubleshooting.						
Need training for healthcare professionals to use the system.						
Need the establishment of a help desk to follow up on system problems and take the appropriate action**.**						

Appendix D: Interview Questions with Medical IT Administrator

- **Arabic Interview questions with Medical IT Administrator**

الاسم_____

المسمى الوظيفي _____

المركز الصحي/المستشفى _____

رقم الجوال _____

الإيميل _____

1. هل لديكم أي فكرة عن قابلية التشغيل البيني مع مؤسسات الرعاية الصحية الأخرى؟ وما هي أهمية ذلك في وجهة نظركم؟:

_____

_____

2. هل يتشابه نظام المعلومات الصحية الإلكتروني في وزارة الصحة الفلسطينية ونظام المعلومات الصحية الإلكتروني في المستشفيات الخاصة وضح ذلك؟

_____

_____

3. ما هي الأنظمة الصحية الإلكترونية التي تعملون بها وما هي خصائصها إن وجدت؟

4. هل توافق على وجوب وجود قابلية تشغيل بيني بين مؤسسات الرعاية الصحية في المراكز الصحية الحكومية ومؤسسات الرعاية الصحية الخاصة مع بيان السبب؟

5. ما هي التحديات في اعتماد التشغيل البيني بين مراكز الرعاية الصحية الحكومية والمؤسسات الصحية الخاصة؟

6. في حال تم انجاز التشغيل البيني ما هي الخدمات والبيانات التي يمكن أن تقدمها مؤسستكم وما مدى الجاهزية عندكم؟

7. ما هي رؤيتك لإمكانية التشغيل البيني في المستقبل القريب؟

8. هل تعتقد أن المعايير مهمة لتنفيذ التشغيل البيني بين مراكز الرعاية الصحية الحكومية والمستشفيات الخاصة؟

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_____

9. هل لديكم أي معايير معتمدة مثل (ICD)، HL7، SNOMED CT ، LOINC ، DICOM ، (ISO؟ إذا كان الأمر كذلك، اذكرهم.

_____

_____

10. كيف يتم الاستفادة من معيار HL7 في تنفيذ التشغيل البيني؟

_____

_____

11. هل يوجد لديكم إجراءات للحفاظ على خصوصية المرضى، وما هذه الاجراءات ان وجدت؟

_____

_____

12. هل يوجد نظام مركزي بين مراكز الرعاية الصحية الحكومية والمستشفيات الخاصة؟

13. ما رأيك في أي نهج يمكن أن يكون مفيدًا مركزيًا أو لا مركزيا للتشغيل البيني بين مراكز الرعاية الصحية الحكومية والمستشفيات الخاصة؟

14. هل تدعم اعتماد البيئة اللامركزية في تنفيذ قابلية التشغيل البيني؟

15. هل النظام الذي تستخدمونه متصل بقاعدة بيانات وطنية او غير وطنية وما هي معايير الاتصال وما هي هذه القاعدة إن وجدت؟

16. هل يمكن لتكنولوجيا المعلومات والاتصالات حل مشكلة التشغيل البيني بشكل آمن مع توضيح؟

17. هل يوجد مبادرات او اقتراحات او اتفاقيات للتشغيل البيني بين منظمات الرعاية الصحية؟

18. هل تعتقد أن وزارة الاتصالات وتكنولوجيا المعلومات قادرة على سد الفجوة في التشغيل البيني بين مراكز الرعاية الصحية وكيف تتطلع الى هذا الدور؟

19. هل تعتقد أن عملية التشغيل البيني من خلال وزارة الاتصالات وتكنولوجيا المعلومات ستكون آمنة وموثوقة؟

20. هل لديكم بنية تحتية تساعد في إنجاز التشغيل البيني، وضح ذلك؟

21. هل يمكن للأطباء الوصول إلى قاعدة بيانات وطنية أو إقليمية للمرضى لدعم اتخاذ القرار (على سبيل المثال، الأدوية، الصور، الحساسية، نتائج المختبر، إلخ) اذكر هذه الانظمة ان وجد؟

22. هل يمكنكم دعم اي اقتراح او نموذج أمن يدعم التشغيل البيني مع التوضيح؟

_____

_____

23. هل وثائق الطبيب (على سبيل المثال، ملاحظات التقدم، وملاحظات الاستشارة، وملخصات الخروج من المستشفى، وقائمة المشكلات / التشخيص، وما إلى ذلك) يتم تنفيذها إلكترونيًا؟

_____

_____

24. ما إجراءات الخصوصية والأمان التي يتم تنفيذها لحماية معلومات المرضى (على سبيل المثال، التحكم في الوصول المستند إلى الدور، والتشفير، ومكافحة الفيروسات / مكافحة البرامج الضارة، وما إلى ذلك)؟ على سبيل المثال: إذا سُرق جهاز محمول (كمبيوتر محمول أو جهاز لوحي)، فهل من الممكن مسح المعلومات المخزنة عليه عن بُعد؟، او إذا هدد أحد المهاجمين النظام بهجوم إلكتروني، فهل من الممكن اكتشافه؟ إذا كان الأمر كذلك، فهل من الممكن منع التهديدات.

_____

_____

25. هل يجري المستشفى تقييمات سنوية للمخاطر الأمنية؟

_____

_____

26. هل يتم تسجيل العمليات الإلكترونية التي تتم على النظام للرجوع إليها في المستقبل لأغراض التدقيق والمساءلة؟

_____

_____

ملاحظات:

- **English Interview Questions with Medical IT Administrator**

Name: _____

Position: _____

Hospital: _____

Phone No: _____

Email: _____

1. Do you have any idea about interoperability with other healthcare organizations? What is the importance of that in your opinion?

_____

_____

2. Is the electronic health information system in the Palestinian Ministry of Health similar to the electronic health information system in private hospitals? Explain that.

_____

_____

3. What are the health information systems that you work with and what are their characteristics, if any?

_____

_____

4. Do you agree that there should be interoperability between healthcare organizations in government health centers and private healthcare centers for a reason?

_____

_____

5. What are the challenges in adopting interoperability between government health care centers and private health centers?

_____

_____

6. What are the challenges in adopting interoperability between government health care centers and private health institutions?

_____

_____

7. What is your vision for interoperability soon?

_____

_____

8. Do you think standards are important to achieve interoperability between government healthcare centers and private healthcare centers?

9. Do you have any approved standards (ICD, HL7, SNOMED CT, LOINC, DICOM, and ISO)? If so, mention them.

10. How is the HL7 standard used in achieving interoperability?

11. Do you have procedures to preserve the privacy of patients, and what are these procedures, if any?

12. Is there a centralized system between government health care centers and private hospitals?

13. What do you think of any centralized or decentralized approach that could be beneficial for interoperability between government healthcare centers and private hospitals?

_____

_____

14. Do you support the adoption of a decentralized environment in achieving interoperability?

_____

_____

15. Is the system you are using connected to a national or non-national database, what are the communication standards and what is this database if any?

_____

_____

16. Can ICT securely solve the interoperability problem with a clarification?

_____

_____

17. Are there initiatives, suggestions, or interoperability agreements between healthcare organizations?

18. Do you think that the Ministry of Telecommunications and Information Technology can bridge the gap in interoperability between health care centers and how is it looking forward to this role?

19. Do you think that the interoperability process through the Ministry of Telecommunications and Information Technology will be secure and reliable?

20. Do you have an infrastructure to help achieve interoperability, explain.

21. Can clinicians have access to a national or regional database of patients to support decision-making (e.g., medications, images, allergies, lab results, etc.?) List these systems if any.

22. Can you support any security proposal or framework that supports interoperability with a clarification?

23. Are physician documents (e.g. progress notes, consultation notes, discharge summaries, list of problems/diagnosis, etc.) performed electronically?

24. What privacy and security measures are in place to protect patient information (e.g., role-based access control, encryption, antivirus/anti-malware, etc.)? For example: If a mobile device (laptop or tablet) is stolen, is it possible to erase the information stored on it remotely? Or, if an attacker threatens the system with a cyber-attack, can it be detected? If so, is it possible to prevent the threats?

25. Does the hospital conduct annual security risk assessments?

_____

_____

26. Are electronic transactions made on the system recorded for future reference for audit and accountability purposes?

_____

_____

Notes:

_____

_____

الملخص

تطور تكنولوجيا المعلومات والاتصالات في العالم يتزايد بشكل مستمر في مجالات الصحة الإلكترونية المختلفة، التي تساهم في تسهيل وتطوير الرعاية الصحية، وتبسيط الإجراءات وتحسين جودة الرعاية الصحية، الذي ينعكس إيجابيا على المرضى والأطباء ومقدمي خدمات الرعاية الصحية. تعاني الصحة الإلكترونية من مشكلة التشغيل البيني بين مؤسسات الرعاية الصحية المختلفة، بهدف مشاركة السجلات الصحية الإلكترونية وتبادلها. تمتلك المراكز الصحية في فلسطين أنظمة معلومات صحية مختلفة، مما جعل مشاركة المعلومات الصحية أكثر صعوبة وتعقيد. يوجد في دول العام المتقدم العديد من أطر العمل والأنظمة التي تدعم التشغيل البيني بين مؤسسات الرعاية الصحية حسب معايير دولية تضمن الخصوصية والأمن، العديد من التحديات تواجه التشغيل البيني في فلسطين من اهم هذه التحديات أمن المعلومات الصحية والخصوصية، والقوانين والأنظمة التي تنظم التشغيل البيني، ولكن من المؤكد أنها ستقدم العديد من الفوائد العظيمة لجميع أصحاب المصلحة (أطباء، مرضى، مقدمي الرعاية الصحية).

يهدف هذا البحث أولا إلى التحقيق في الوضع الحالي لاعتماد السجلات الصحية الإلكترونية في فلسطين، بالإضافة إلى مدى استعداد المراكز الصحية المختلفة لتنفيذ التشغيل البيني، وثانيا اقتراح إطار عمل تقني مناسب للتشغيل البيني، الذي يحقق التبادل الآمن للسجلات الصحية الإلكترونية بين مختلف مؤسسات الرعاية الصحية في فلسطين.

تم استخدام المنهج المدمج لتحقيق أهداف البحث، حيث كشفت النتائج النوعية المستندة إلى المقابلات مع متخصصي تكنولوجيا المعلومات في العديد من مستشفيات الرعاية الصحية الخاصة والعامة في فلسطين إلى أن الأنظمة الصحية المستخدمة في المؤسسات الخاصة تختلف عن الأنظمة الصحية في المؤسسات العامة، بالإضافة إلى إجماع الجميع على ضرورة تنفيذ التشغيل البيني، وتمت مناقشة تحديات التشغيل البيني، منها الأمن والخصوصية والتكاليف العالية وعدم وجود بنية تحتية كافية، بالإضافة إلى عدم توف المعايير اللازمة للتشغيل البيني. أجمع الأشخاص الذين تم مقابلتهم على استخدام البيئة اللامركزية للتشغيل البيني في فلسطين، وعلى أهمية التشغيل البيني وفوائده

الكبيرة للمرضى والأطباء ومقدمي خدمات الرعاية الصحية، أيضا هناك إجماع على أن تكنولوجيا المعلومات والاتصالات قادرة على تنفيذ التشغيل البيني الآمن. أظهرت النتائج الكمية من خلال تحليل الاستبيانات تحديات التشغيل البيني وفوائده بالإضافة إلى متطلبات التشغيل البيني التقنية والمعلوماتية حيث أوضح التحليل إلى الفائدة الكبيرة للتشغيل البيني للمرضى وأصحاب المصلحة من وجهة نظر العاملين الصحيين ودعمهم لتنفيذه في فلسطين، بالإضافة إلى تحديات التشغيل البيني. أكدت الدراسات الكمية والنوعية أنه لا يوجد تبادل إلكتروني للسجلات الصحية الإلكترونية بين مراكز الرعاية الصحية الخاصة والعامة، وأكدت على ضرورة تنفيذ التشغيل البيني لتحسين جودة الرعاية الصحية في فلسطين ومواكبة العالم في التطور التقني الصحي.

بناءا على هذه النتائج، اقترح الباحث إطار عمل للتشغيل البيني الآمن في فلسطين تمتلكه وزارة الاتصالات وتكنولوجيا المعلومات الفلسطينية، يسمى (UXP/XROAD) لمشاركة السجل الصحي الإلكتروني بتنسيق قياسي يمكن لأجهزة الحاسوب والتطبيقات المختلفة استخدامه.