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Sudan University of Science and Technology

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A BI-Based Framework for Improving Decisions in the Healthcare

إطار عمل مستند على ذكاء الأعمال لتحسين إتخاذ القرار في المجال الصحي

A thesis submitted in fulfillment of the Requirements for the degree of Doctor of Philosophy in Computer Science

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April 2021

الآية

بسم الله الرحمن الرحيم

قال الله تعالى:

(كَمَا أَرْسَلْنَا فِيكُمْ رَسُولاً مِنْكُمْ يَتْلُو عَلَيْكُمْ آيَاتِنَا وَيُزَكِّيكُمْ وَيُعَلِّمُكُمُ الْكِتَابَ وَالْحِكْمَةَ وَيُعَلِّمُكُمْ مَا لَمْ تَكُونُوا تَعْلَمُونَ ۝ فَاذْكُرُونِي أَذْكُرْكُمْ وَاشْكُرُوا لِي وَلا تَكْفُرُونِ)

سورة البقرة:151، 152

Dedication

I dedicate this dissertation to the memory of my mother Sabeha, my father Hassan, my wife Nafisa, lovely kids Hassan, Ahamed, Musab and Ameen. Also, to my friends, and the faculty of Sudan University with its professors, for their care, unwavering support.

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Abstract

Healthcare emergence and trend lies on the new technologies of the ITC. It has greatly increased the health institutions in Sudan, which receive huge numbers of patients on a daily basis. The main suffering in healthcare come from poor data that has been traditionally stored in repository formats making it difficult to analyze or use effectively. Inconsistencies, and lacks integration of data, producing confusion for healthcare stakeholders to making decisions, which leads to many problems in this sector, including, loss of lives. This study aims to propose a new framework for improving decisions making in the healthcare domain based on BI implementation to be advantageously applied to the health system's infrastructure data. Furthermore, investigating the benefits of implementing BI in the healthcare sector to enhance the decisions processes base on the real information using three case study (providers, Time, and Service management). A hybrid model approach was used to develop a BI implementation in Sudanese healthcare sectors. The proposed hybrid model tends in gathering data and exploring the main factors affecting its adoption, to achieve the research objectives. Qualitative and quantitative analysis methodologies and exploratory interviews were used in identifying the factors affecting on the BI implementation and their associated factors. The results have enhanced the healthcare process in two fold; first the real time dashboard by storing, integrating and retrieving healthcare information. Second using knowledge discovery in terms of providers and services waiting time through data mining technique to 11% and 18% respectively.

المستخلص

يكمن التحول لاتجاه ونمو الرعاية الصحية في استخدام التقنيات الحديثة لتقنية المعلومات في مؤسسات ومراكز الرعاية الصحية. مما أدى إلى زيادة وتوسع في المؤسسات الصحية في السودان بشكل كبير، والتي تستقبل أعدادًا كبيرة من المرضى بشكل يومي. تأتي المشكلة الرئيسية في الرعاية الصحية من ضعف البيانات التي يتم تخزينها بصورة تقليدية في مستندات ورقية مما يجعل من الصعب تحليلها أو استخدامها بشكل فعال. نجد أن التناقضات، وعدم تكامل البيانات، ينتج عنه ارتباك لأصحاب المصلحة في مجال الرعاية الصحية لاتخاذ القرارات، مما يؤدي إلى العديد من المشاكل في هذا القطاع، بما في ذلك الخسائر في الاموال الأرواح. تهدف هذه الدراسة إلى اقتراح نموذج عمل جديد لتحسين اتخاذ القرارات في مجال الرعاية الصحية على أساس تطبيق ذكاء الأعمال ليتم تطبيقه بشكل مفيد على بيانات البنية التحتية للنظام الصحي. علاوة على ذلك، التحقيق في فوائد تطبيق ذكاء الأعمال في قطاع الرعاية الصحية لتعزيز عمليات اتخاذ القرارات على المعلومات الحقيقية بالتطبيق على ثلاثة دراسات حالة تتضمن (مقدمي الخدمات، والوقت، وإدارة الخدمة). تم استخدام منهج النموذج الهجين لتطوير تطبيق BI في قطاعات الرعاية الصحية السودانية. يميل النموذج الهجين المقترح إلى جمع البيانات واستكشاف العوامل الرئيسية التي تؤثر على اعتماده، لتحقيق أهداف البحث. تم استخدام منهجيات التحليل النوعي والكمي والمقابلات الاستكشافية في تحديد العوامل التي تؤثر على تنفيذ ذكاء الأعمال والعوامل المرتبطة بها. لقد عززت النتائج عملية الرعاية الصحية في شقين؛ أولاً لوحة التحكم البياني في الوقت الفعلي من خلال تخزين ودمج واسترجاع معلومات الرعاية الصحية. ثانيًا، استخدام اكتشاف المعرفة لمقدمي الخدمة وذلك من خلال تقليل وقت انتظار الخدمات من خلال تقنية استخراج البيانات إلى 11٪ و18٪ على التوالي.

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Abbreviations

Acronym	Description
HC	Healthcare
BI	Business Intelligence
DSS	decision support system
OLAP	Online Analytical Processing
EMR	Electronic Medical Records
PHC	Public Healthcare
PDMS	Patient Data Management System
PACS	A picture archiving and communication system
HIPAA	Health Insurance Portability and Accountability Act
KPIs	Key Performance Indicators
WHO	World Health Organization
ACO	Accountable Care Organization
SHCFM	Sudanese Health Care Framework
MOH	Ministry Of Health
ICT	Information and Communication Technologies

Publications

1. Salih H. Babiker and Izzeldin A. Elhassan, "*Review of Business Intelligence Implementation in Healthcare*", IJCTT 68.7 (2020):24-30.

2. Salih H. Babiker and Izzeldin A. Elhassan, "Business Intelligence Implementation in Healthcare - A Case Study in Sudan", IJCTT 68.12 (2020):4-10.

CHAPTER I

CHAPTER I

INTRODUCTION

1.1 OVERVIEW

The research subject is introduced to focus on the healthcare stakeholders intention to optimize their decision-making processes by analyzing historical data in a timely manner, while streamlining operations, and controlling cost to expansion competitive advantage (Boonsiritomachai et al., 2014). The rapidly growing use of Information and Communication Technologies (ICT) by industries and businesses to support their environments has led to generating huge amounts of data from several transactions (Palanisamy and Thirunavukarasu, 2017).

The healthcare sector has complex processes, and involves a variety of stakeholders with countless interrelationships and varying interests. These stakeholders include medical staff, insurance companies, government, regulating agencies, service providers, medical suppliers, and above all patients, who need the provision of reliable and affordable services(Moore, 2014). Maintaining and managing all of these interconnected relations between these stakeholders is very difficult without the use of technology. Furthermore, these correlations are more critical in healthcare than in other industries and businesses as they involve the human life and wellness, they contain both legal and moral intersections (Moore, 2014). For these reasons, it is essential to implement ICT in healthcare to gain the benefits of technology utilization toward facilitating processes, improving services, and the sharing of data (Blomberg and Karasti, 2013).

Currently, technology and its applications are widely used in healthcare, even in developing countries like Sudan. Examples are, Hospital Information Systems (HIS), Enterprises Resource Planning (ERP), and specialized applications such as Radiology Information Systems (RIS), etc. These systems facilitate healthcare processes and services but at the same time face many

challenges. Some of which are technical including the rapid development of medical technologies, their mounting costs, and data integration and security issues (Hübner et al., 2010). Additionally, there are non-technical issues such as, the rising expectations and entitlements of patients, and the affordability of services either from cost or quality care perspectives.

The widespread application of the aforementioned healthcare systems has necessitated the need to investigate and identify the main characteristics or factors influencing the successful implementation of healthcare systems. These factors create pressure to: (1) increase stakeholders' access to healthcare information, (2) grow the variety of medical services, (3) change the approach to financing and managing of healthcare, (4) stress the growing importance using of ICT in the healthcare sector (Gaardboe and SVARRE, 2018). Recent research (Gaardboe et al., 2017), has shown that one of the best indicators of systems' effectiveness is stakeholders' satisfaction. On one hand, the patients' healthcare provider of choice is preferably close to their homes, provides quality care, with affordable cost, accurate diagnoses, with minimal medical errors and minimum waiting time. All of these factors comprise what is referred to as patients' satisfaction. While on the other hand, healthcare service provider's objective is to reduce costs, increase revenue, while improving services' quality and achieving their most desirable target, i.e., patients' satisfaction. Providers aim at increasing patients' visits frequency while maintaining their satisfaction and that of the medical and administrative staff by continuously improving the environment (LouranZ, 2012).

The rapidly increased of information and use of technology that follows a motivation to improve, and dedicated to describing how the healthcare industry takes recently advantage of the implementation of IT into account, and how the current situation of work in that sector develops, in several countries where the aim is to improve the provision of quality of care information to healthcare executives, managers and clinicians, to target organizational strategies to achieve clinical improvements and increase patient safety (Quix et al., 2013), (Olszak and Batko, 2012).

The Sudanese healthcare systems face many challenges due to demographic changes, technological advances in medicine, and the limited possibilities to increase healthcare funding, and auditing the quality of service, requiring more intensive solutions for the effectiveness of the systems. So it became necessary to identify the factors affecting Sudanese healthcare systems, including rising costs of medical services, the rapid development of medical technologies, changing disease patterns, raising the expectations and entitlements of patients, large-scale inefficiencies in healthcare, the stress to increase access to healthcare, the growing diversity of medical services, changes in the approach to financing and managing of healthcare and the growing importance of IT in the sector(Health, May 2014). Therefore, the solution to this problem seems to be the appropriate to using the IT in the healthcare sector, especially those that facilitate access to data and information and enables the support of decision-making processes and reports in real-time (Singh, 2012).

This problem manifested in terms of the very low access to PHC in Sudan. One-quarter of the population has no access to health facilities with considerable regional, urban, and rural disparity. Many rural areas are underserved by the health system in terms of functional facilities, in particular, health centers and hospitals, which are found to be clustered in towns and cities. It should be noted that 33.2% of the population lives in urban regions. Furthermore, the minimum PHC package is provided by 19% of PHC facilities, which gigs the efficiency and quality of PHC services. Therefore, one of the major problems of Sudan's health system delivery is the lack of optimal access to high-quality PHC services, the lack of information and using remote diagnosis (LouranZ, 2012).

1.2 Sudan Healthcare Background

Sudan is one of the eastern African countries with a land area of 1.8 million square kilometers; its population is nearly 31 million people with 33.2% out of the population living in an urban setting while 8% are nomads. Almost 2% of the population is within displaced. The average household size is 5-6 persons, while the fertility rate is 3.9. Life expectancy at birth is 59.8 and the annual death rate is 16.7% out of the total population. The health services provided are

organized based on the Sudan federal system of governance at three levels of administration: primary, secondary, and tertiary (Ebrahim et al., 2017). This is based on the recently endorsed health systems standards following a consultative process involving states (Specifications and Standards for Health System in Sudan 2010). The total of public health in all three levels in 2012 in 426 hospitals according to a WHO report. And the Sudanese health sector is focused on the provision of primary healthcare with some secondary healthcare provision (both public and private sector provision).(Health, May 2014)

The Sudanese health system divided to three categorize as the services providers, firstly government healthcare organizations provides some primary or advance healthcare services, it directed by ministry of healthcare either federal or state ministry of health and there are provides strategic direction to Ministries of Health allocate. The Secondly private healthcare organizations**,** provides most of populations percent specially when the governmental healthcare services it became careless services and not available almost of the time, and also in recent time the private healthcare sectors it became the cornerstone of healthcare process. The thirdly special governmental organization such as the Police and Security and Armed Services have their own network of medical facilities that provide services to serving and retired personnel and their dependents, and also serving some time the general population under concern condition (Ebrahim et al., 2017),(Hassan et al., 2018).

To illustrate the relation between Sudanese healthcare, categorize compose the cycle of healthcare systems to represent the type of steps for healthcare services delivery to the patients, that shown as Figure 1-1 below:

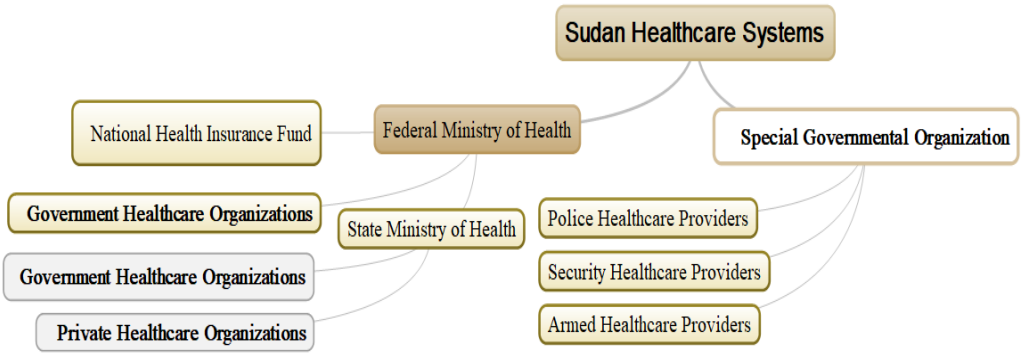

Figure 1-1 Sudanese Healthcare Systems(Ebrahim et al., 2017)

Figure1-1 represent the sudanese healthcare systems, that illustrate the Federal Ministry of Health provides strategic direction, and it is responsible for policy-making, strategic planning, coordination, and harmonization of all health actors' actions and plans including national and international players, providing technical support and guidance to states, and monitoring and evaluating of the overall health system performance (Elsayed, 2004).

The State Ministries of Health it is the ultimate level found the localities representing the local health system, and concerned mostly with policy implementation and service delivery, and also responsible for the healthcare services providers on the state level and collect the statistical report from there to forward the Federal ministry after analysis and summarized (Cometto et al., 2010).

The special governmental organization reflect special network of healthcare providers (Police, and Security and Armed Services) have their own medical facilities that provide services to serving and retired personnel and also sharing some of information with ministry of health as statistical report. and the private sector predominantly based in Khartoum provides secondary care, but now there are many private medical complex center in many states as healthcare providers as spatial healthcare, but they reported statistical report to ministry of health (Elsayed, 2004).

The National Health Insurance it is coordinate with federal ministry of healthcare either form fund perspective or prevalence of diseases, including chronic ones, which places greater demands on the healthcare delivery system , reported to the ministry of health, that provides the budget and plan to operational units and

hospitals, as well as the economic support to operational units and the strategy to improve the infrastructures of hospitals, education, and training of the population and staff, to prohibit and deal with chronicle and very contagious diseases (like HIV/AIDS, Ebola, Cholera, Malaria), (Armellin, 2011).

At the ultimate level reconstructed the localities representing the local health system, and concerned mostly with policy implementation and service delivery. They are based on district health systems. challenges facing the health care sector it can be summarized as at either real and accurate statistical data, or lack of and information to get a planning proportion of accurate or correct information based on the historical data using analyzing tools, and also lack of homogeneity and the method of analysis, and so there is a very large information gap between them and service centers.(Health, May 2014). Challenge remains in the amount of data and information that is available daily in hospitals where there are no connections or technique. Statistics of the deaths resulting from some diseases endemic or infectious (Malaria, pneumonia, Asthma, HIV...etc.)(Report, 2015) remain unmanaged because of the distances and the amount of data collected and the traditional way, and Sudan is fragmented due to the parallel information generation. As a result, this also leads to poor quality of health information, inconsistent standards to collection and participation of data, and non-ability to acquire health information at the time and place where it is needed. In the following, some statistical figures are shown, presented from the Ministry of Health in 2012(Green, 2012).

Figure 1.2 represent the reported to the ministry of health, that its data provides from the sequences of healthcare systems content the statistical information, to prohibit and deal with chronicle and very contagious diseases (like HIV/AIDS, Ebola, Cholera, Malaria).(Health, May 2014) (Armellin, 2011).

ICD	Diseases	Cases	%	Death Cases	% Death of Cases
A01.0	Pneumonia	115,911	12%	955	0.8%
O80	Normal Delivery	110,445	12%	53	0.0%
B54	Malaria	107,029	11%	618	0.6%
A09	Gastroenteritis	58,146	6%	322	0.6%
O82	Caesarean	53,656	6%	44	0.1%
N81	Obstetrics and Gynaecology	39,304	4%	106	0.3%
J45	Asthma	31,061	3%	96	0.3%
L02	Cutaneous Abscess	17,847	2%	72	0.4%
R69	Unknown and Unspecified	17,593	2%	718	4.1%
E13	Diabetes Mellitus	17,046	2%	376	2.2%
Top 10		568,038	60%	3,360	0.6%
Others		380,114	40%	9,755	2.6^
All		948,152	100%	13,115	1.4%

Source: Federal Ministry of Health

The following figures illustrate the distribution of inpatients by age, gender and disease.

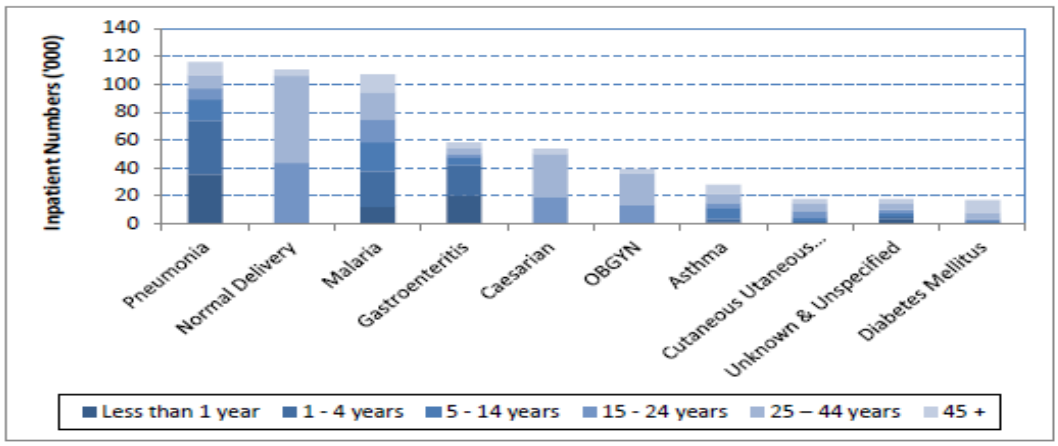

Figure 1-2 Inpatient Cases Treated at Hospital(Armellin, 2011, Health, May 2014)

The ministry of health and the governing bodies need to know which are the real needs to improve the healthcare for the population and also to identify and deal with an emergency, to plan effectively set activities like the continuous and periodic monitoring required by contagious diseases and endemic diseases, morbidity, and death rate reason, and to reduce waste of resources and operational cost (Elsayed, 2004).

Based on these analyses the ministry of health can better plan for public health interventions, and make accurate decision, for example to grant appropriate number of beds in a hospital or health posts facing critical health crisis. and also there are many restrictions of analysis and development in this sector like environment, social, economic and technological, such as various challenges, lack of qualified personnel and of IT, data collected by devices and tools is scarce and not trustworthy, lack of data or poor hospitals' information, no coverage of comprehensive health to get health state of population, limitations of networks and

infrastructure, no information and communication technologies or electricity and computers available, lack of information systems. Furthermore, people do not see any useful results in a short time coming out. These factors leave the data collection process incomplete and non-useful, and error-prone (Armellin, 2011, Ebrahim et al., 2017).

From the discussion above in the introduction to the current status of countries as explained above in terms of health and the current state of the healthcare sector and how to deal with policies to manage this field, demand for an improvement of this industrial sector particularly concerning linking the human health with beneficially managing information, knowledge, and data. For this reason of complexity, it is essential to implement IT into healthcare to gain the benefit of using technology toward facilitating processes and improving services , especially those that facilitate access to data and information and enables the support of decision-making processes and reports in real-time (Olszak and Batko, 2012).

1.3 Problem Statement

Based on the interviews that done in health care Sudanese hospitals and centers, the problems were; the difficulties of availability of information from healthcare data, based on huge amount of data that is sometimes collected manually on papers, or redundant data from variety sources (Ebrahim et al., 2017). In addition, the lack of integrated data within one hospital or between different hospitals can lead to human errors that affect the decision making.

1.4 Research Significance

The anticipated benefits of this research are the improved and informed decisions in the healthcare domain based on a multifaceted view on past and recent data and extracting the right information at the right time due to the implementation of BI and DSS technologies in the Sudanese healthcare sector, to achieving efficiency and effectiveness in the healthcare industry. Furthermore, this research contributes to the conceptual and theoretical understanding of BI and business analytics as well as its utilization and benefits within healthcare. It also describes the

opportunities this growing research area brings to healthcare sectors alongside with major challenges associated with its exploration and implementation.

Moreover, this research is significant as it highlights the overwhelming complexity of healthcare DSS as it relates to patients and services providers, where limited research has been done. It also provides an opportunity to improve the quality of services provided and the improvement the level of medical service in Sudan.

It is in the prospect that the proposed BI framework will serve the convergence of all the data from various systems and formats and the foundation of a central healthcare DW. This will facilitate the exploration of trends; provide information for making planning and policy formulation and making an accurate decision to serve the healthcare operation, as well as comparing the quality of the different healthcare providers.

The proposed solution will give healthcare decision-makers, service providers as well as patients the opportunity to make decisions based on real fact-based knowledge since it provides an easy presentation of all structure and unstructured data, allows identifying new opportunities and making sound predictions.

This research and the related concepts are easily transferrable to businesses and environments other than healthcare and at the same time, they can be extended to include further aspects of healthcare, too. In addition, the significance of this research is postulated in the opportunity to advance the research area by publishing in reputable academic journals to make the approaches and results available for a global research and development auditorium.

1.5 Summary of Related Work

Several studies have been conducted in the area of healthcare sectors. Most of the previous studies considered research adopting BI technologies in the healthcare sector based on various approaches. One such approach explores utilizing the available open-source BI tools and their applicability in the clinical sphere taking into account the general characteristics of the healthcare sector environment (Palanisamy and Thirunavukarasu, 2017),(Brandão et al., 2016). Another approach

uses the well-known DeLone and McLean Information Systems (IS) success model (Wang et al., 2018a);(Gaardboe et al., 2017, Wang et al., 2018b). Similarly, (Naderinejad et al., 2014); (Yeoh and Koronios, 2010) has shown that the success of BI implementation in the healthcare domain requires three-dimension factors. These are, (1) organization factors, process factors, and technology factors. Each of these three dimensions has many factors that are referred to as Critical Success Factors (CSFs), that are defined as "the limited number of areas in which results if they are satisfactory, ensure successful competitive performance for the institute", or "the few key areas where things must go right to achieves their goals" (Rockart, 1979).

In addition, a great number of papers were reviews in this study, are based on the use of BI from a perspective, administrative and financial purposes, and all most also focused on improved patient care, quality of service, reduced costs and improved efficiencies, and financial performance by using key performance indicators, increased efficiency, and accuracy of planning, budgeting, prediction, using different BI tools such as data mining dashboards or data warehouse and reporting of them using data mining, OLAP.. etc. In other way, some of the articles considered some aspects like adaptability, scalability, standardization, maintainability, and security and readability.

This research will thoroughly consider the great importance of benefit of the implementation of BI and using its tools in the healthcare sector from a special perspective that it must be conceded that is not complete in open issues and gets its result by validating the models from the viewpoint of providers management, time management and how to create competitive advantage between healthcare institutes to improve healthcare environments and reduce the service, and operational cost, and try to courage service converge in one place. Taking into account previous studies conducted in this area, which are reviewed in this chapter of the thesis, that divided into three-session, on the first sessions the using of BI in healthcare,

Table 1- 1: Summary of related work

Author	BI Implementation Focus	BI Tools Used	Objective

Ashrafi, Noushin Kelleher, Lori Kuilboer, Jean-Pierre 2014	*Improve the healthcare delivery in the USA by using BI capabilities to support the healthcare institutes achieve their effectiveness to improve quality care and reduce cost. How BI creates a combination of data to extract useful information to support decision making(Ashrafi et al., 2014).*	*DW, Mathematical Techniques*	*Improve Services, Data Integration*
Olszak, Celina M Batko, Kornelia 2012	*Discussed the current healthcare situation in Poland and how to achieve the full benefits of BI implementation based on historical data collected, to enhanced decisions making process and to improve the patient outcomes, quality of medical services, and reduce costs, instead of the further improvement of medical necessity as the essence of BI in healthcare sectors (Olszak and Batko, 2012).*	*DW, DM*	*Enhance Decisions , Data Integration,*
Gaardboe, Rikke Nyvang, Tom Sandalgaard, Niels 2017	*Empirically tested the DeLone-McLean IS success model on a BI system applied to 12 healthcare systems in Denmark. The success factors of BI implementation are system quality, information quality, use, user satisfaction, individual impact. The purpose of the study is to investigate which factors contribute to BI success (Gaardboe et al., 2017).*	*Mathematical Techniques*	*Improve Services, Financial Performance, Patient Satisfaction*
Naderinejad, Marjan Tarokh, Mohammad Jafar Poorebrahimi, Alireza 2014	*Explore whether BI implementation is affected by applying the Critical Success Factors (CSFs) model of BI (organizational, process, and technological) factors? To achieve intelligent healthcare institutes and its certainty is a high priority of service quality, taking into account the complexity of the relationship between these factors and the satisfaction of healthcare stakeholders in making accurate*	*ETL*	*Improve Services , Enhance Decisions, Patient Satisfaction , Data Integration*

	decisions(Naderinejad et al., 2014).		
Magdi, Dalia Ahmed 2019	*Implementation of a DW to enhance operational and financial prospects. Factors including quality, cost-effectiveness, clinical, integration, and running costs reduction(Magdi, 2019).*	*DW, DM*	*Detect & Predict Disease, Improve Services, Financial Performance, Patient Satisfaction*
Obeidat, Muhammad North, Max Richardson, Ronny Rattanak, Vebol North, Sarah 2015	*Investigate if emerging technologies and the implementation of BI systems have a positive effect in the healthcare domain. Focusing on these three main factors: service quality, cost reduction, and managing risks. The research showed that BI adoption was helpful in chronic disease management(Obeidat et al., 2015).*	*DM, OLAP, Data Integration , Real-Time Processing*	*Detect & Predict Disease, Improve Services , Financial Performance, Patient Satisfaction*
Khedr, Ayman Kholeif, Sherif Saad, Fifi 2017	*Improve results in the healthcare sector obtained from healthcare institutes systems by conducting Framework result. Using BI to provide stockholders with accurate decisions based on enhancing the analytics information from integrating healthcare data using analytical tools(Khedr et al., 2017).*	*DW, DM, OLAP, ETL*	*Enhance Decisions , Data Integration*
Pereira, Ana Portela, Filipe Santos, Manuel Filipe Machado, José Abelha, António 2016	*Use the implementation of BI systems to serve healthcare, and became more useful at Intensive Cares Unit(ICU) to make decisions, by creating availability of pervasive patient's and getting more positive aspect for patients' safety and care, improve the quality, reduce medical errors and, consequently(Pereira et al., 2016).*	*Mathematical Techniques*	*Improve Services, Patient Satisfaction*
George, Joseph Kumar, V Kumar, S 2015	*Approve using of optimal DW structure for implementation of BI concepts on the healthcare sector to get accurate decision to improve healthcare quality and*	*DW, DM, ETL*	*Improve Services, Enhance Decisions, Financial*

	also reduce the cost, improving patients care(George et al., 2015).		*Performance, Patient Satisfaction, Data Integration*
Davidson, MD Arthur, J 2015	*Is the implementation of BI tools leveraging in the healthcare sector to achieve patient safety and healthcare institutes financial effectiveness and improve the healthcare sector by increasing efficiency and outcomes, reducing costs, this improving through the targeted BI application of health analytics (Davidson and Arthur, 2015).*	*DW, DM, OLAP, Data Integration*	*Improve Services, Financial Performance, Patient Satisfaction*
Brooks, Patti El-Gayar, Omar Sarnikar, Surendra 2015	*The readiness of healthcare institutes to developing its sector by conducting a BI framework, use to create a domain-specific BI maturity model in the healthcare sector to achieve positive of critical success factors for BI implementations is healthcare based on a conceptual structure readiness to improvement either operational or financial and clinical (Brooks et al., 2015).*	*ETL, mathematical techniques*	*Improve Services, Financial Performance*
Haque, Waqar, Bonnie Urquhart, Emery Berg and Ramandeep Dhanoa 2014	*How BI techniques and tools can be applied to healthcare environment using its system data to achieve this information more accessible and intelligible for healthcare stakeholder to make informed decisions based on BI implementation regarding resource allocation and enhancement of the quality of patient care(Haque et al., 2014).*	*DW, OLAP, Data Integration*	*Improve Services, Data Integration , Enhance Decisions*
Chen, Edward T 2014	*Using BI tools to get accurate, informed decisions in the healthcare sector by extracting meaningful information from the data. Considered three technical issues to achieve the impact of the design, build, implementation, and support of the system (Chen, 2014).*	*DW, ETL*	*Enhance Decisions*

Karami, Mahtab Fatehi, Mansoor Torabi, Mashallah Langarizadeh, Mostafa Rahimi, Azin Safdari, Reza 2013	*The opportunity of BI adoption in the healthcare sector to achieve strategic goals and objectives, and impacts to improve the healthcare institute's performance from many affecting factors, such as operations, finance, quality, eliminate information asymmetry specially in the radiology unit(Karami et al., 2013).*	Data Integration	Improve Services, Data Integration
Muraina, Ishola Dada Ahmad, Azizah 2012	*The capabilities of BI techniques to facilitate decision-making in a university hospital. Study to determine the diseases that require crucial attention among the students' patients, using DW for forecasting future activities to know the medical statistics (Muraina and Ahmad, 2012).*	DW, ETL	Detect & Predict Disease
Kolowitz, Brian J Shresth, RB 2011	*The effectiveness of IT on the healthcare domain and their impact on the healthcare process. using federated Picture Archiving Communication Systems (PACS) as a case study for implementation BI to enhance the availability of information, to informed decisions and improve healthcare sectors to get intelligence knowledge management and clinical workflow(Kolowitz, 2011) .*	Data Integration, Real-Time Processing	Improve Services , Data Integration
Ahmed, Soha El Seddawy, Ahmed Ibrahim Nasr, Mona 2019	*How to detect and predict diseases through BI applications. DM techniques were used to help expedite diagnosis and prediction of diseases. Diabetes was used as a case study to detect and predict the disease from the patient complications(Ahmed et al., 2019).*	DW, ETL	Improve Services, Enhance Decisions , Financial Performance, Patient Satisfaction, Data Integration

Table 1-I represents a summary of the reviewed research papers with a short description that contains their scope, purpose, results, and contents of the work. In

the following section, additional literature classifications will follow, that focus on the BI technologies utilized, stakeholders, and the targeted BI objectives and contributions to the healthcare sector.

1.6 Research Hypotheses

This research will introduce three hypotheses that will be summarized through three view point as follow:

1. Using BI technologies in the Sudanese healthcare sector will grant an optimal manipulation of data, and the data will be stored into DW to the decision making in Sudanese healthcare stakeholders.

2. Using BI technologies in the Sudanese healthcare will be reflected in good quality of service and enhance the healthcare sectors through:

    a. Reducing the patient waiting time to get a diagnosis or result or treatment.
    b. Providing historical patients information leading to reliability and credibility, reducing medical errors, operational cost, employee's effort, as well as uncertainty and concerns about the disease diagnosis, treatments, and their effectiveness.
    c. Enhance the healthcare environment either for the staff by gating jobs satisfaction, or the patient's satisfaction environments.
    d. Reduce the expenses and increase the revenue of services for any healthcare institutes using the BI Tools.

3. Using BI technologies and tools will enhance the decision making and knowledge Discovery.

Based on the above discussion, this research is based on the hypothesis that utilizing a BI framework to enhance the Sudanese healthcare sectors, would yield higher levels of services providers, provide potential policy decision-support regarding healthcare planning, and quality of services and affordable cost.

To support this hypothesis, fulfill the study and achieve its purpose, more information that explains the approach that will be followed throughout this research, is provided in Chapter 3 “Research Methodology and Approach”.

1.7 **Research Methodology**

The research methodology will follow four stages which are; first investigate the user requirements. Then study the plan technology based on the implementation of BI in the Sudanese healthcare sector, to improve informed decisions for the stakeholders. Third, a mixed model research approach will utilize to involves collecting, categorizing, analyzing, and interpreting data using both quantitative and qualitative to support the representation of data in the healthcare lifecycle. Fourth, design the proposed framework that content of four layers which are; i) Operational data. ii) Data ware house. iii) BI technology. v) Knowledge decision making.

1.8 Research Questions

RQ1: What are the requirements needed for BI implementation in the Sudanese healthcare industry, in terms of the environmental factors that may affect the proposed BI framework, including the potential stakeholders, the target group, preprocess to integrate data sources, that may provide valuable input to the framework?

RQ2: What are the advantages of a BI framework to enhance the decisions making in the healthcare industry?

RQ3: How the proposed framework is enhancing the healthcare sector in terms of time, provider and service management and reduce services cost?

1.9 Research Objectives

The main objective of this research is to enhance the Sudanese healthcare sector, by proposing a Sudanese BI healthcare framework that can be a basis for computerized systems toward.

This objective can be divided into four sub-objectives:

1. To Study similar experiences and best practices in attempting to reach the suitability of the envisaged application of these techniques in the healthcare sector by review the literature about BI technologies utilization in general and specifically in healthcare sectors.
2. To Identify information life cycle of Sudanese's healthcare organizations (hospitals, health centers, and clinics). In addition, identify the healthcare stakeholders, to gather data from these healthcare organizations and to achieve the integration of information through DW concept to enhance the decision making.
3. To investigate the suitability of the implementing BI for healthcare sector. By investigate environmental factors influencing the proposed BI framework, in term of techniques or data that used in the in terms of structure, homogeneous, format and integration of data.
4. To proposed a framework that optimizing Sudanese's healthcare sectors, enhance healthcare services, reduce the service waiting time, and reduce the services cost, in term of decision making concept.
5. To validate the efficiency of outcomes of the proposed framework that can help healthcare stakeholders in decision making that must be ensure adequate quality of service, and patient satisfaction.

1.10 Research Scope

In line with the explanations in the previous sections, the proposed BI framework will be an answer to the question of how can we effectively utilize and improve the Sudanese healthcare system based on the application of supportive BI technologies. Accordingly, this research will concentrate on three main parts:

1. The first part will explore the Sudanese healthcare sector data and information systems, through the BI Definition, it is an umbrella term that combines architectures, tools, databases, analytical tools, applications, and methodologies. It represents the ability of an organization to manipulate its own data, and sometimes external data, to produce knowledge and forecasts.
2. Hence the at this stage of the research, we BI and appropriate tools will be defined, for example, DW concept, data mining technologies in a way for providing a healthcare data mining, or statistical technologies, and this depending on the scope

of the particular business problem to be solved in the given environment. OLAP and DW are technologies or concepts that were introduced and widely used prior to the advent of BI, as will be explained in Chapter Tow. Further, BI Systems are built around the concept of a DW with OLAP and DM, along with other technologies, used to exploit information in order to support making better decisions

3. The main technical tools using is Microsoft SQL Server BI tools were used for the case study implementation (Microsoft.com, 2020). These tools support BI services concepts by utilizing SQL Server Analysis Services (SSAS) as technology from the Microsoft BI stack to develop (OLAP) solutions, and SQL Server Reporting Services (SSRS) to create reports from multiple data sources with wealthy data visualization either charts or maps, Rapid Miner as DM tools for creating Knowledge discovery.

1.11 Thesis Structure

In this Chapter of the thesis, an introduction to the research topic was given with some background information about healthcare sectors in general, and the current situation in Sudan then the research's hypothesis is presented ,and highlighting the main research problem background, then the problem itself is defined, then reflect the problem into three research question, then highlighting the research objectives and break it down into four sub-objectives , and also represent the outlines of the research significance, and the research scoop, and then end create summery of chapter (1).

Chapter {2} outlines the theoretical background overview of the research, followed by definition of BI with illustrate the BI architecture and components, relation between DSS and BI followed by of BI in healthcare, after that covers the literature review.

Chapter {3} Explains the approach and methodology used in the research the is give a detailed explanation about data collection from various healthcare stakeholders as study targeted groups, by data sources and stakeholder's identification, then explain the data preprocessing before extraction of data from the repository of database

content huge data in a different format, and also includes research about the use of BI and its components in healthcare sectors.

Chapter {4} starts with over view of framework proposal for the implementation of the BI in the Sudanese healthcare sectors improving informed decisions, and represent the proposed solution framework architecture with an in-depth explanation of the conceptual data model and its logical model whit their relational data model, and also explorer the components of the framework proposal in deep definition, then discuss the data analysis , then describe the case study that improve the efficiency of the framework models.

Chapter {5} describes the approach to validation the efficiency of BI framework based on the obtain of the results to explain information of each case study, the steps of validation the efficiency by many results based on the case study factors and correlation between the case study and its factors from various perspectives, to covers model efficiency, proof-of-concept implementation objective.

Chapter {6} provides a summary of the research objectives, conclusion and contribution. while is ends with the future works.

CHAPTER II

CHAPTER II

THEORETICAL BACKGROUND

2.1 Overview

They are many technology tools can support organizations to improve efficiency in managing information for decision making, but in the healthcare there are another factors it must be taking into account, integration, privacy and security of information, and the trust of information and tools, however in this thesis focus to using BI tools in the healthcare to help stakeholders to understand their complex processes and relationships by means of easily assimilated, and how to customized visual dashboard that help stakeholders to taking timely and informed decisions, and take actions that will improve performance of healthcare sectors (Ferranti et al., 2010).

In this chapter we'll make a light on the what is BI by defined it in several ways based on its uses, and their tools, and also make a highlighting for BI components and architecture and create concept of uses of BI in healthcare domain, as well as constrain and reservations that must be considered, then create comparison between DSS and BI.

2.2 BI Definition

BI is a relatively new and very promising area in information systems, and refers to the ability to collect and analyze massive amount of data concerning to institutes stakeholders processes, (Chee et al., 2009). is a set of abilities, tools, techniques, and solutions that help institutes stakeholders to understand their business situation (Rouhani et al., 2012).

BI is defined in several ways based on its uses but it is part of the general IT framework. In 1958, the researcher (Luhn, 1958) used the expression BI and defined it as the "ability to understand the interrelatedness of current data in many sides as to lead decision in respect of a wanted purpose and gain the competitive advantage"

(Kumari, 2013). However BI is seen today in many aspects in terms of decision support systems DSS, data warehouses, OLAP, reporting, etc.

BI is becoming an umbrella expression regarding the increased data in organizations to picture "concepts and methods to improve business decision making by using real data based computerized support systems." (Kumari, 2013).

The research of (Delone and McLean, 2003) focus on success model, tested an applied of BI on HIS, to determine which were significant, information quality associated with User Satisfaction as is System Quality. Therefore, it would be useful to measure the effects of BI applied on a healthcare sectors level. because BI helping the healthcare stakeholders to enhance this sectors in a short and long term under many conditions and estimate alternative treatments based on data analyses.

BI consists of three steps: data storage integration, analysis, and presentation information. Many industrial sectors usually use BI dashboard tools in the presentation phase to deliver the information to stakeholder, and end users (JINPON, 2011). Then the solution in the adaptive BI architecture aims to gain high quality data and consistent and correct that described at the following paragraph.

2.3 **BI** Architecture and Components

From what we have learned so far, we recognize that the BI concept was software tools that content and utilize many techniques and tools, to achieve knowledge from the information after collecting, storing, analyzing that information to enhance the process of decision-making in any institutes. BI systems deal simultaneously with structured and unstructured data, This, in turn, leads to creating insight from information that can be used in the present and in the future (Ferranti et al., 2010, Kumari, 2013).

(Duan and Da Xu, 2012, Singh, 2012) have identified the following four major components of BI systems:

2.3.1 Data Warehousing (DW)

Data Warehousing provides storage space for thematic stowage of integrated, aggregated and analyzed data, so far the DW aggregated transactional data, transformed and stored for analytical purposes, to get optimized for aggregation and retrieval of large data sets, which makes it easier to analyze. Moreover, the DW represents a model of enterprise data, especially structured for facilitating querying and analysis processes on integrated and consolidated data. The main goal of a DW is to enable business users to make effective tactical and strategic decisions based on factual data, by representing knowledge in a timely and accurate. There are many definitions for the DW, the common of them say the term "Data Warehouse"(Inmon, 2005):

- A DW is a subject-oriented, integrated, time-variant, and nonvolatile collection of data in support of management's decision-making process."
- subject-oriented: organized around major subjects, such as customer, supplier, product, sales, etc.
- integrated: constructed by integrating multiple heterogeneous sources, such as relational databases. Data cleansing and data integration techniques are applied to ensure consistency in naming conventions, encoding, etc.
- time-variant: changes to the data in the DW are tracked and recorded so that reports can be produced showing changes over time.
- nonvolatile: data is never overwritten or deleted - once committed, the data is static, read-only, but retained for future reporting.

To conclude this section of defining a DW as an integral part of BI systems, it is a better-explained component of DW as (Figure-2-1) below, two represent the processes of the DW are metadata repository and data preparation.

2-

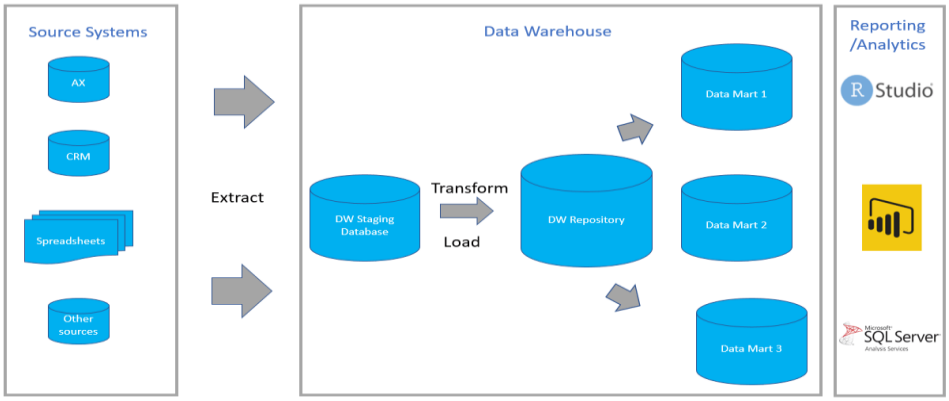

Figure 2-1: DW Components (George et al., 2015)

2.3.2 Extract-Transform-Load (ETL)

Extract-Transform-Load tools that are responsible for data transfer from operational or transaction systems to DWs, and also data preparation is also called ETL, and it involves the integration of data from multiple source systems and performing data cleansing where variations in data schemas and data values from disparate transactional systems are resolved, in preparation for their Loading into the DW as a data consistent database.

2.3.3 On-Line Analytical Processing (OLAP)

On-Line Analytical Processing tools that allow users access and which analyze and model business problems and share information that is stored in DW. However, OLAP tools enable users to slice and dice, pivot, sort, filter data to see patterns that help in making better decisions.

2.3.4 Data Mining (DM):

Data Mining tools for determining patterns, generalizations, regularities, and rules in data resources. Moreover, many DM techniques are practiced by various businesses, the most dominant include prediction, classification, association and clustering. DM along with OLAP are essential components of the business analytics phase of the BI system.

Many DM techniques are practiced with various businesses, the most dominant include prediction, classification, association and clustering. DM along with OLAP are essential components of the business analytics phase of the BI system, in this research using Rapid Miner as one of DM techniques, to achieve the Knowledge thought BI Framework Model.

2.3.5 Reporting

Ad-hoc inquiry and reporting tools: for creating and utilizing different synthetic reports; and presentation layers that include customized graphical and multimedia interfaces to provide users with information in a comfortable and accessible form.

2.3.6 **Microsoft SQL server BI**

It is tools were used for the case study implementation (Microsoft.com, 2020). These tools support BI services concepts by utilizing SQL Server Analysis Services (SSAS) as technology from the Microsoft BI stack to develop (OLAP) solutions, and SQL Server Reporting Services (SSRS) to create reports from multiple data sources with wealthy data visualization either charts or maps.

As illustrated ordering of BI components (Figure-2-2) below, (Rouhani et al., 2012) many article mention to a good BI system must provide and content the following capabilities for any institutes; production reporting, end-user query and reporting, OLAP, dashboard/screen tools, DM tools, and planning and modelling tools

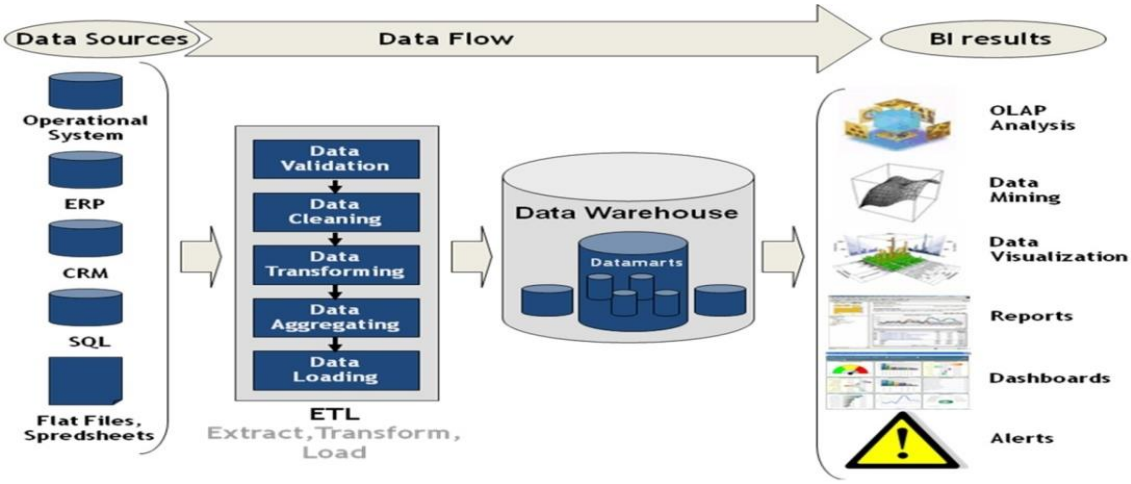

Figure 2-2 BI Components Architecture (Krmac, 2011)

Finally, the Gartner Group forecasts that BI and business analytics will continue to expand in the foreseeable future more rapidly than the overall market. The emerging BI trends include mobile analytics, in-memory analytics, BI embedded in collaboration and social software and cloud-based BI.

2.4 BI in Healthcare

Each organization intends becoming an intelligent organization and achievement competitive advantage on the market by implementing new technology and innovative BI solutions. The capabilities of BI in the healthcare sector to transfer volumes of data from various sources into a common depot to enable analysis and drill down into certain aspects and creating prudence of operational process to provide decision support mechanism (Ashrafi et al., 2014, Gurjar and Rathore, 2013). .. However, challenges in the healthcare sector are more complex than other business such as privacy issues, decision makers in the healthcare sector meet the multifaceted challenges of quality, cost and compliance with laws and regulations and patient specific requirements, based on both clinical and administrative data (Ashrafi et al., 2014).

In recent years, BI technologies have been applied to various sectors in order to support the decision-making process. because BI enables the extraction of knowledge from the data stored for each sectors. Thus, there is existing research analyze some open-source of BI tools on the market and their applicability in the

clinical sphere for example QlikView, Palo, Jaspersoft, Tableau, Spago, and Pentaho , taking into account the general characteristics of the healthcare sectors environments (Brandão et al., 2016).

Using BI for enhancing the analytics of healthcare sector will support improve the results and information obtained from such systems, that systems integrated with BI framework to analytics healthcare sectors operational DB, that framework composed from common BI component andtiers in general (Khedr et al., 2017).

There are many motivations that make the implementation of BI and its tools in healthcare sectors so important, one of them the needs for transfer of data into information and knowledge, to making decision based on actual information, and sharing of information, abilities to translate analyses and use it in management properly, improve efficiency, and needs of healthcare sectors to heterogeneous , and dynamism integration of data, because the complexity of its data and high sensitivity is aspect of healthcare , beside the context of huge data volume in this sectors (Gaardboe and SVARRE, 2018, Olszak and Ziemba, 2007).

The demand for using BI technology in the health care sectors is became considered , regarding to the complexity and larger data in this sectors(George et al., 2015), in spite of believed the data structure positively influence the efficiency of BI solutions (Boonsiritomachai et al., 2014) ,(Ivan and Velicanu, 2015).

2.5 DSS and BI

BI is a broad category of applications and technologies for gathering, storing, analyzing, and providing access to data to help enterprise users make better business decisions, but the Decision support system (DSS) is a computer program application that analyzes business data and presents it so that users can make business decisions more easily,

DSS - decision support systems are appeared as a concept during the 1970s and 1980s, the concept of (DSS) grew and evolved out of two previous types of computer support for decision making. One was management information systems (MIS), which provided (1) scheduled reports for well-defined information needs, (2) demand reports for ad hoc information requests, and (3) the ability to query a

database for specific data. The second contributing discipline was operations research/management science (OR/MS), which used mathematical models to analyze and understand specific problems.

The definition of DSS, which has evolved since the 1970s and prevails today, was described in Building Effective Decision Support Systems define as (Airinei and Homocianu, 2009):

- Computer-based systems
- That help decision makers
- Confront ill-structured problems
- Through direct interaction
- With data and analysis models

The Type of DSS in terms of their primary driving source of information we can describe it from five categories perspective as the following (Power, 2002):

- Data driven DSS: Based on emphasize access to and manipulation of large databases of structured data and especially a time-series of internal company data and sometimes external data. includes file drawer and management reporting systems, data warehousing and analysis systems, Executive Information Systems.
- Model driven DSS: Based on emphasize access to and manipulation of a model. Simple statistical and analytical tools provide the most elementary level of functionality, includes systems models, representational models, and optimization models.
- Knowledge driven DSS: Based on suggestion or recommend actions to stakeholders related with specialized problem-solving expertise, using a related concept is Data Mining.
- Document driven DSS: Based on integrates a variety of storage and processing technologies to provide complete document retrieval and analysis.
- Communication driven and group DSS: Based on communication driven DSS includes communication, collaboration and coordination and focus on supporting groups of decision makers to analyses problem of situations and performing group decision making tasks.

As illustrate above (Figure-2-3) below make clearer concept and introduce pictorial summary of BI and DSS components.

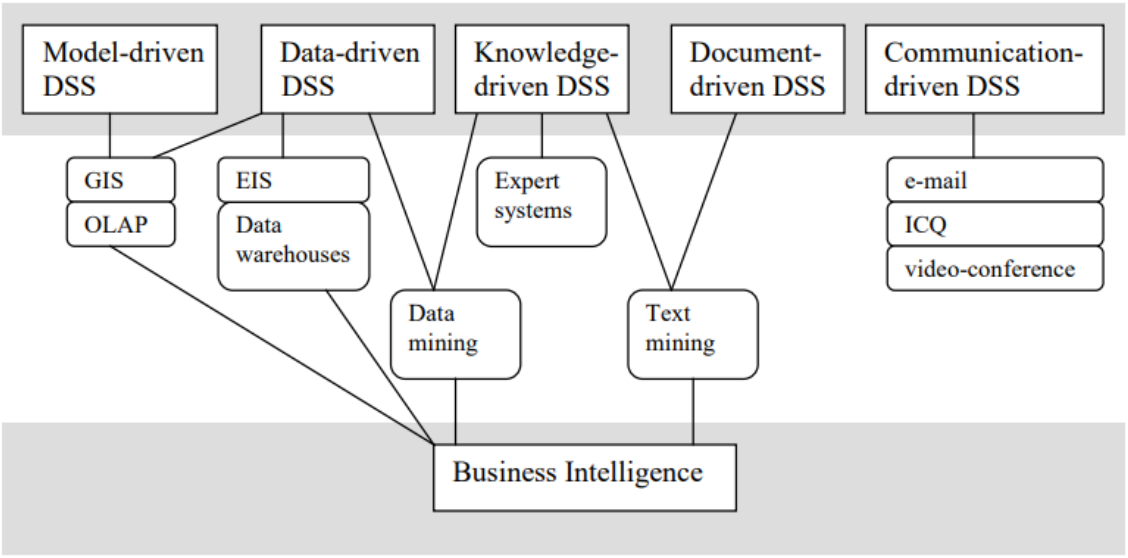

Figure 2-3: Components of BI and DSS(Kopáčková and Škrobáčková, 2006)

Figure 2-3 clearly explain content similarity between BI and DSS. We can conclude now that the branch of BI is developing and future components can be absolutely different based on the institutes and its business, and the type of DSS.

2.6 LITERATURE REVIEW Overview

The use of BI in healthcare, like any other technology-based approach, is to resolve business challenges and streamline operation. As discussed earlier, challenges in the healthcare sector are more complex and interrelated than other businesses and industries. Examples of these challenges include, maintaining the privacy and confidentiality of patients clinical and administrative information, improving service quality, reducing cost, enhancing time management, and complying with laws and regulations (Goodman, April 2010),(Miller et al., 2011) .

2.6.1 LITERATURE REVIEW

In today's healthcare sector, there is no shortage of data, but in fact; organizations are located above a huge pool of data. The research article(JINPON, 2011),(Armellin, 2011) (Armellin, 2011, JINPON, 2011)(Armellin, 2011, JINPON, 2011)discuss several factors needed to be considered when we apply BI in public health. However, they focus on the importance of understanding internal as well as external influences on the organization, detecting opportunities for innovation to

allow for best decision making in the healthcare sector, and concrete on BI optimizing regarding integration, storage, analysis, and presentation of data (JINPON, 2011, Armellin, 2011).

The use of BI systems and its tools has helped health systems developed in this sector by achieving many benefits, based on the functionality that is used, so improvements in healthcare quality, safety, efficiency, financial performance, reduce risks caused by an environmental source, data access to get statistics, get new knowledge, ensure the quality of the care and patient security, reduce costs, by using BI tools (JINPON, 2011). But the some article focuses only on the use of dashboard tools, and how the dashboards can present critical information in a form that will allow quick decisions, spatially the ability to present new trends and correct errors (Elias, 2012).

BI tools and DW using can be used to present a good result through utilizing benchmark key performance indicators (Chen, 2014). However, to improved patient care, quality of service assurance, reduced costs, and improved efficiencies of operational information, and financial performance identified potential technical issues taken into account and considerations from managerial aspects like adaptability, scalability, standardization, maintainability, and security (Haque et al., 2014).

The research article (Armellin, 2011, Haque et al., 2014, JINPON, 2011, Kern et al., 2012) demonstrated use of analytic tools to improve healthcare at lower costs ,and concerns about privacy and information security, using an EMR in the healthcare provides forms for clinicians. But (Yadav et al., 2014) demonstrate to mining concepts in healthcare by describing patterns of data, using data mining in the healthcare to improve this sector by using reformed data to reanalysis, and discover disease clusters towards specific location which leads to better policy making to detect and manage disease outbreaks. However, To be effective, they must rely on current KPIs, intelligently analyzed and presented for rapid decision-making (Moore, 2014).

The research article (Naderinejad et al., 2014) aimed at recognition of critical success factors (CSF) is necessary for each business sector or project, and so

certainly, applying BI gets many advantages for healthcare sectors, take into account (quality, repetition, Integration) of data in BI. According to Yeoh and Koronios (Yeoh and Koronios, 2010), CSFs can be classified into three dimensions: organization, process, and technology. Organizational dimension includes such elements above (Naderinejad et al., 2014). However, determine and rank CSFs to implement BI in hospitals that factors affecting implementation of BI in hospitals by using Cochran's formula and Friedman Test.

The research article (Armellin, 2011, Haque et al., 2014, JINPON, 2011) demonstrated how BI techniques and tools can be adapting in the healthcare environment to produce informed decisions regarding optimal use of resources and the realization of efficiency, to increasing the services quality of patient care. However, the OLAP is a BI tool built to allow see data along several dimensions determined by various KPIs. The article (Olszak and Batko, 2012) discusses mainly dashboard generating and reports based on data collected through the BI system to get better business performance, which can fulfill the progressive needs of BI in the healthcare domain that serves all the diverse measurements and performers spatially (Magdi, 2019).

In addition, we can reduce operational equipment and consumables by the implementation of BI technology, whether material, pharmaceuticals, or medical. We can achieve effectively and facilitated clinical decisions inaccurate time. Using BI analytics tools in the healthcare sector improves patient satisfaction, patient treatment, and care as well as care outcomes. Healthcare professionals can access patient’s data very easy and they can create any type of reports upon demographic data, sex, age, and so on (JINPON, 2011). Moreover, BI systems ensure the patient's safety by a decrease in medical errors and sufficient exchange of patient medical information in a larger healthcare system. They allow us to detect all types of irregularities, fraudulent, deception, and decrease duplication of work. All of these benefits contribute to taking good decision by the organizations’ authorities in the health sector and serve the thorough organizations’ policy (Goodman, April 2010, Olszak and Batko, 2012).

Several healthcare have huge data stored in proprietary or incompatible formats, some of this data might be useful for improvement of decision , when adopting BI

system s(Kolowitz, 2011). However BI has support organizations to understand complex processes and relationships by providing an inclusive view of the organizational data, taking into account the privacy of healthcare data challenges must be addressed (Ferrand et al., 2010, Poon et al., 2006). Therefore, the systems must be simple to both, integration as well as simplicity to use, to provide information leading to better decision making following the patient privacy rules and trusted information. Additionally, the information generated via BI tools should produce valuable results that are easily interpreted by the end users and kept in a confidential stage.

The adoption of HIT in Sudan remains in its infancy, and there is a significant variance in adoption between stakeholders. Despite the daunting challenges that lie ahead, Sudanese policymakers and healthcare institutions should take heart in the fact that other industrialized countries (Australia, Germany, the U.S.A.) have been successfully deploying the HIT to improve the quality of care, either in the Nurse System or PACS. All of the HIT serve to achieve the efficiency of work as well as the patient satisfaction and reduction of the cost (Hübner et al., 2010). Further more research is needed to determine the specific level of usefulness and impact on the users and the patient care, and enhance the decision-making in healthcare sectors, according to the implementation of BI tools and DSS from any perspective.

The benefits of adopting BI in the healthcare domain can be large, and is influenced by various factors because BI has no benefit without available data, to analyze the information to get improved performance, considerable business benefits including the following (Elias, 2012):

i. The capability to optimize resources in the healthcare providers.
ii. The capability to develop and monitor KPI to enhance healthcare sectors performance and quality.
iii. The capability to conduct planning, budgeting, and forecasting.
iv. The capability to effectively understand and manage the medical supply.
v. The capability to better ensure patient safety.

There are many potentials of using KPIs to enhance the healthcare sector through BI adoption, but the problem comes especially when data are collected from various

sources by diverse methods in diverse sectors, hospitals (Ferrand et al., 2010, Miller et al., 2011, Naderinejad et al., 2014). Despite the use of KPIs or identifying patient-oriented KPIs, which measure how well services providers gets the effectiveness and efficiency in the service (Perjons and Johannesson, 2011),(Saade et al., 2015). However, there is broad literature available on using BI in many fields, relatively few of them are in the healthcare field and even less in the clinical practice of medicine, to enhance the healthcare sectors.

Research by (LouranZ, A.M,2012) demonstrated how BI techniques and tools could be used in the healthcare environment to make informed decisions regarding resource allocation and enhancement of the quality of patient care. The healthcare providers that will be able to respond to rapid changes, get new market opportunities (Karami et al., 2013). However, in the proposed thesis the focus is on the deployment of BI capabilities in the healthcare industry by addressing relevant issues and challenges and offering examples of how BI technology has impacted the problems of accessibility, cost, and quality of healthcare delivery.

The implementation of BI in healthcare sectors allows to handling data from the various data sources by aggregation layer. because data will be intelligently processed to get performing the acquisition of data from healthcare, and transformation of this data after restructured, and storage(Wang et al., 2018a),(Wang et al., 2018b). However, primary goal of data acquisition from hospitals is to read data provided from various communication channels, frequencies, sizes, and formats taking into account categories of big data analytics capabilities of analytical capability for patterns of care data.

In today's healthcare environment, there is no shortage of data, but in fact, healthcare organizations are swinging in an ever-deeper pond of data. The challenge is how to convert the huge amount of available data to suitable knowledge and information.BI solutions for information and gathering data, processing, and distribution cover many interactive capabilities that make healthcare having immediate access to knowledge that allows offering quality care with a low-cost organizational memory, information integration, insight creation, and presentation. This all makes BI essential for every industry and specifically, healthcare organizations, underlying at the same time the enormous demand for deep need an understanding of BI and its

capabilities as approached by this thesis. The healthcare sector is extremely dependent on information but so far no technology extracts data, then transforms it into information in real-time to take accurate decisions based on that information. The data itself (not useful sometimes and unmanaged also) are only a bit more than useless. So far, only the BI technology is eligible to focus on key indicators, and easily and speedily provide valuable information for healthcare organizations. Information obtained in this manner may be used in the daily work of medical facilities for clinical diagnoses and patient treatment, administrative and financial decisions, an order of performance healthcare services and medicines, optimal use of equipment, and more.

2.6.2 Review Analysis

The objective of this review is to investigate which facets of healthcare could be improved by the adoption of BI tools and techniques, and how. This is achieved through identifying and highlight from the literature the BI components, how they were applied, and the results realized from such utilization.

For this purpose, and on a high-level review, the literature is categorized into two groups: namely, research that investigates the CSFs required for the successful adoption of BI in healthcare on one hand. And, literature that explores the goals and benefits of BI adoption in healthcare on the other. According to the literature (Naderinejad et al., 2014),(Brooks et al., 2015),(Gaardboe and SVARRE, 2018), the CSFs include system quality, information quality, BI use, user satisfaction with the BI implementation, and what users are able to do with BI tools as individual impact. BI maturity model is measured by organization, process, and technological factors to demonstrate the efficacy of the framework by applying it to the development of a BI in healthcare.

The second group of literature explores the benefits and goals intended from adopting BI in healthcare. It is obvious that the overarching goal is improving the healthcare services as a whole, but each research focuses on its own perspective or area of improvement. A review is conducted of research goals depending on its intended objective, contributions, and outcome as shown in Table I. All of the reviewed literature in this category target improving either medical and/or administrative facets or aspects of healthcare. The medical aspects include how

the adoption of BI in healthcare supports the medical staff in detecting and predicting diseases and as such improve decision-making. Another area is how the adoption of BI improves medical services by availing and integrating medical departmental information to stakeholders. Other facets include, reducing medical errors, patients' safety, and the most desirable target patients' satisfaction. On the administrative aspects side, the focus is on managerial and financial factors, for example reducing cost, increasing revenue, improving services quality, decision-making, integrating administrative departmental information, etc.

While all the reviewed literature target healthcare improvement in the sector, most only focus on BI adoption at a single healthcare institute. Because BI by its definition enables data integration and aggregation for decision-support, we believe that sharing a regional or national DW better exploits BI strengths and achieves the utmost benefit from its adoption. This area of research, i.e., that aggregation and sharing of data across healthcare institutes in the sector requires more research.

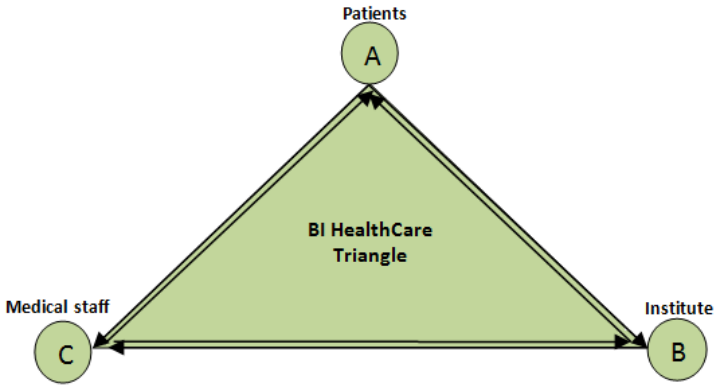

Figure 2-4: BI Healthcare Core Stakeholders

From the literature review, we determine that all the healthcare beneficiaries are stakeholders of BI adoption in the sector, including, governments, communities, healthcare institutes, healthcare staff, and the patients. The three main beneficiary groups or core stakeholder of BI adoption are, patients, healthcare institutes, and medical staff since they directly interact with, influence and are influenced by BI application. On the other hand, there are many relationships between these main stakeholders, as illustrated in our healthcare service triangle in Fig.2-4. These bidirectional relationships include patients' need for service that is provided by

medical staff who work for the institutes. The service providers in return aspire for financial returns, and good reputation from the patients**.**

The following is a summarization from the literature of the benefits of adopting BI for each of the three core stakeholders' groups.

A. Patients

Healthcare is an essential universal requirement of populations in all countries around the world. Patients and their satisfaction, is the cornerstone of healthcare service, its enhancement, and the ultimate goal of BI implementation in the sector. The patients' satisfaction factors are covered by most of the reviewed papers, and all were improved by the BI implementation.

B. Medical Staff

They include physicians, nurses, medical assistants and technicians. Through all the reviewed literature, all the medical activities that are carried-out by staff became more efficient with BI. Many clinical and diagnostic factors of the healthcare process were improved, including reducing medical errors and inaccurate diagnoses. Also, the process of predicting and detecting diseases and trends is greatly enhanced by mining through the wealth of available historical data. As a result, improvements were reported in the literature about service quality to patients, which is one of the main objectives of BI and technology adoption as a whole.

C. Healthcare Institutes

Throughout the literature, there is consensus that healthcare institutes have realized many advantages through the implementation of BI. These include, decreasing running costs and increasing revenue and information availability to their stakeholder. The availability of such timely historical information helped in improving administrative decisions related to institutes' management and this was reflected patients' services.

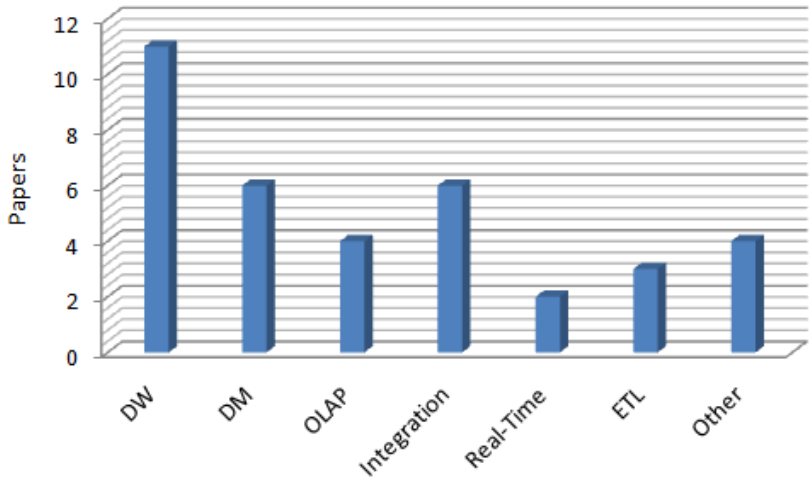

Figure 2-5: BI Technologies

Switching to the issue of BI components utilized, the reviewed literature includes investigation of the implementation of complete BI suites as well as separate components and technologies. Fig.2- 5 recognizes and classifies the BI technologies adopted in healthcare implementations in the reviewed literature. Clearly, every research paper reviewed could adopt more than one technology or technique, and the most technology used based on Fig.2- 5 is the DW. This is an expected finding, as the DW is the core BI component around which the whole BI framework is developed since it integrates and aggregates data. The second most frequently employed BI technologies are data integration and mining. The two are vital technologies for trend analysis, drill-down and predication.

The following classification of the reviewed literature is based on their BI implementation objectives, CSFs, and their advantage to the three main stakeholder groups outlined earlier. Based on the previous discussion about the IS success model, and the literature, we recognize the following six CSFs groups:

1. Detect and Predict Disease

Analyzing historical information is one of the main advantages of BI tools, especially in the healthcare domain, where huge data is available either in the local repository or the DW. BI technologies enable predicting and detecting diseases, not for specific patients' but for chronic disease trends, or seasonal epidemiology. This serves patients by saving their lives, and the healthcare sector by improving performance.

2. Improve Services

Healthcare service improvement is the cornerstone of the healthcare enhancement process because it affects the quality of both operational and clinical services. The main objective of all healthcare stakeholders is the improvement of the healthcare quality either operational or clinical.

3. Enhance Decisions

Improving the decision-making process is one of the main targets of BI in the healthcare sector. The BI tools and technologies make the information available to stakeholders. One of the key BI features is the drill-down through the DW to investigate trends and predict. This helps medical staff to quickly diagnoses dieses and saves patient's life.

4. Financial Performance

Managing and controlling operation and other costs are the top motivators for healthcare institutes to implement BI. Minimizing cost and maximizing revenue is a primary target, especially if the institutes are of a profitable nature.

5. Patient Satisfaction

This is a universal indicator of the quality of the healthcare sector. The literature groups all the following factors under the patients' satisfaction category: patients' safety, medical errors reduction, cost reduction, service quality, and favorability of services.

6. Data Integration

In healthcare, patients' historical information is critical and timely, especially in intensive care or emergency units. The integration of data assists in the providing information to make timely, accurate and informed decisions. This is a fertile area of research in the healthcare sector, i.e., the integration of medical and administrative information.

Table 2-1: Main Implementation Objective

BI Main Objective		Reference
1	Detect & Predict Disease	(Obeidat et al., 2015), (Muraina and Ahmad, 2012),(Ahmed et al., 2019)
2	Improve Services	(Ahmed et al., 2019), (Gaardboe et al., 2017),(Gaardboe and SVARRE, 2018) , (Naderinejad et al., 2014), (Magdi, 2019),(Pereira et al., 2016) , (George et al., 2015),(Davidson and Arthur, 2015) ,(Brooks et al., 2015) , (Haque et al., 2014),(Karami et al., 2013) ,(Kolowitz, 2011) , (Obeidat et al., 2015),

3	Enhance Decisions	(Ahmed et al., 2019), (Olszak and Batko, 2012), (Naderinejad et al., 2014), (Khedr et al., 2017),(George et al., 2015) , (Haque et al., 2014),(Chen, 2014) ,
4	Financial Performance	(Ahmed et al., 2019),(Magdi, 2019) , (George et al., 2015), (Davidson and Arthur, 2015), (Brooks et al., 2015) , (Obeidat et al., 2015)
5	Patient Satisfaction	(Ahmed et al., 2019),(Naderinejad et al., 2014) , (Magdi, 2019), (Pereira et al., 2016), (George et al., 2015), (Davidson and Arthur, 2015), (Obeidat et al., 2015)
6	Data Integration	(Ahmed et al., 2019), (Olszak and Batko, 2012), (Naderinejad et al., 2014), (Khedr et al., 2017), (George et al., 2015), (Haque et al., 2014), (Chen, 2014), (Karami et al., 2013), (Kolowitz, 2011)

Table 2-1 summarizes the BI implementation objectives of the reviewed research based on the six core CSFs. As explained earlier, these CSFs were derived from research on the IS success model for BI in healthcare. It is reassuring that Table II shows that the most prevalent BI objective in the literature is "Improve Service". This is followed by "Data Integration" because the integration of information leads to improving the decision-making process and eventually the healthcare service as a whole.

2.7 Discussion:

During the journey of objectives achievement, and literature review, the following general open issues have been identified that if addressed, will improve the implementation of BI and DSS in the healthcare sector as well as the processes of decisions making and support:

2.7.1 Improving decision in the healthcare sector based on the BI systems advantages by minimizing the lack of information by transform the base of information from papers to a knowledge-based on historical data, and managed data unstructured to increasing the quality of data, identifying the data repetition, integrating data for all available sources, timeless reporting. All these factors will affect the decision in the healthcare organization. On the other hand, the different environments lead to more challenges because of the geography of countries and the nature of the data used, as well as standards and regulations on the confidentiality of information. Further, not all services are obtainable in all countries or communities. Thus, data and system interoperability issues have a high impact.

2.7.2 Many articles demonstrate how BI techniques and tools can be used in the healthcare environment to make informed decisions regarding resource distribution and increase the quality of patient care, and some did not focus on the time factor, whether waiting for service, or time of delivery. to make information more accessible and intelligible for a broader group of people, the resulting decision support reports can be kept up to date based on the recent data that is all right. Then, the effectiveness of using BI and DS tools to get the performance and to gain satisfying solutions for industrial organizations, either in healthcare or business, raises enormously.

2.7.3 Analyzing the most widely used BI tools, the technical BI and DSS specifications and requirements also bear uninvestigated issues. For example, an area of further research is mobile, cloud, and embedded system solutions. but from the perspective of application solution, it's not demonstrate managing wastes of time and get competitive between institutions to infect the patient's interest. This intended thesis needs to determine what is the best to be implemented locally in the Sudan healthcare sector and how the proliferation of certain diseases or eradication of other diseases can be reduced by improving informed decisions in the healthcare domain based on the implementation.

2.7.4 The use of BI and DSS tools to get competitive advantages in healthcare is good in any way because decisions are based on past and recent information that is analyzed and also provides forecasting opportunities. However, the challenges of how to create a suitable model to meet the particular needs of the healthcare sector to achieve that competitive advantage for infect of patient's interest. the most important healthcare organizational trend is to reduce the operational cost especially after a deterioration of services in public health organizations from the multitude and government spending, to increase the revenue, especially for profit-oriented organizations, also the trend of the government to reduce cost and get optimal use of the resources, for example using consumables and life-saving drugs, anesthesia drugs, etc. Thus, cost consideration and process optimization represent the most important driving factor that must be embedded in BI and DS from the perspective of patient satisfaction and good service.

2.8 Summary

Obviously, BI applications have been under investigation and are being utilized internationally across many healthcare institutions(Mettler and Vimarlund, 2009) . Therefore, there is consider able research that analyzes and discusses adopting BI technologies in the healthcare sector based on various approaches. One such approach explores utilizing the available open-source BI tools and their applicability in the clinical sphere taking into account the general characteristics of the healthcare sector environment (Palanisamy and Thirunavukarasu, 2017),(Brandão et al., 2016)Another approach uses the well-known DeLone and McLean Information Systems (IS) success model to investigate the adoption of BI technologies in the sector (Wang et al., 2018a);(Gaardboe et al., 2017, Wang et al., 2018b). Correspondingly, research (Naderinejad et al., 2014); (Yeoh and Koronios, 2010) has shown that the success of BI implementation in the healthcare domain requires three-dimension factors. These are, (1) organization factors, such as managerial support, commitment and sponsorship, (2) the process factors, including adoption plan, team composition, interactive development approach, and user interaction, and (3) technology factors, such as, framework scalability and flexibility, and sustainable data quality and integration. Each of these three dimensions has many factors that are referred to as Critical Success Factors (CSFs), that are defined as "the limited number of areas in which results if they are satisfactory, ensure successful competitive performance for the institute", or "the few key areas where things must go right to achieves their goals" (Rockart, 1979).

Therefore, this research will thoroughly consider the great importance of benefit of the implementation of BI and using its tools in the healthcare sector from a special perspective that it must be conceded that is not complete in open issues and gets its result by validating the models from the viewpoint of hospital Staff management, time management and how to create competitive advantage between healthcare institutes to improve healthcare environments and reduce the service, and operational cost, and try to courage service converge in one place. Taking into account previous studies conducted in this area, which are reviewed in this chapter of the thesis, that divided into three-session, on the first sessions the using of BI in healthcare. Most of these papers, which were reviews in this secession, are based on

the use of BI from a perspective, administrative and financial purposes, and all most also focused on improved patient care, quality of service, reduced costs and improved efficiencies, and financial performance by using key performance indicators, increased efficiency, and accuracy of planning, budgeting, prediction, using different BI tools such as data mining dashboards or data warehouse and reporting of them using data mining, OLAP.. etc. .and some of the article taken into account and considerations some aspects like adaptability, scalability, standardization, maintainability, and security and readability. and in the second secession the needs of using BI and its tools in the healthcare sectors to extracts data, then transform it into information in real-time to take accurate decisions based on that information.

CHAPTER III

CHAPTER III

RESEARCH METHODOLOGY AND APPROACH

3.1 Overview

In previously sections, defining the research problem has led to breaking down the main research objective into four sub-objectives. To achieve these objectives, this research starts with a comprehensive exploration of literature concerning BI in general, Healthcare sectors and hospitals for the purpose of collecting operational data to revise and polish the objectives. This includes exploring the existing processes, data, and healthcare data sources in Sudan, while recognizing key stakeholders and factors that are involved in the whole healthcare process and services providers with patient's lifecycle.

Based on the identified information from the various sources, and the data gathering from three hospitals, a BI data model will be proposed with a strategy to integrate data for building a DW using different development stages. Iterative validation of the efficiency and enhancements of the model will be carried out combined with technical implementation.

The basic BI implementation model was developed based on the proposed framework. Then a discovery of the main factors involved in its successful adoption in the Sudanese healthcare sector was conducted. Content analysis was utilized for this investigation together with an exploration of key stakeholders' assessment of the identified factors. Finally, an implementation case study is utilized to investigate the value and effectiveness of the proposed BI framework that represents at cycles in Figures 3-1 below:

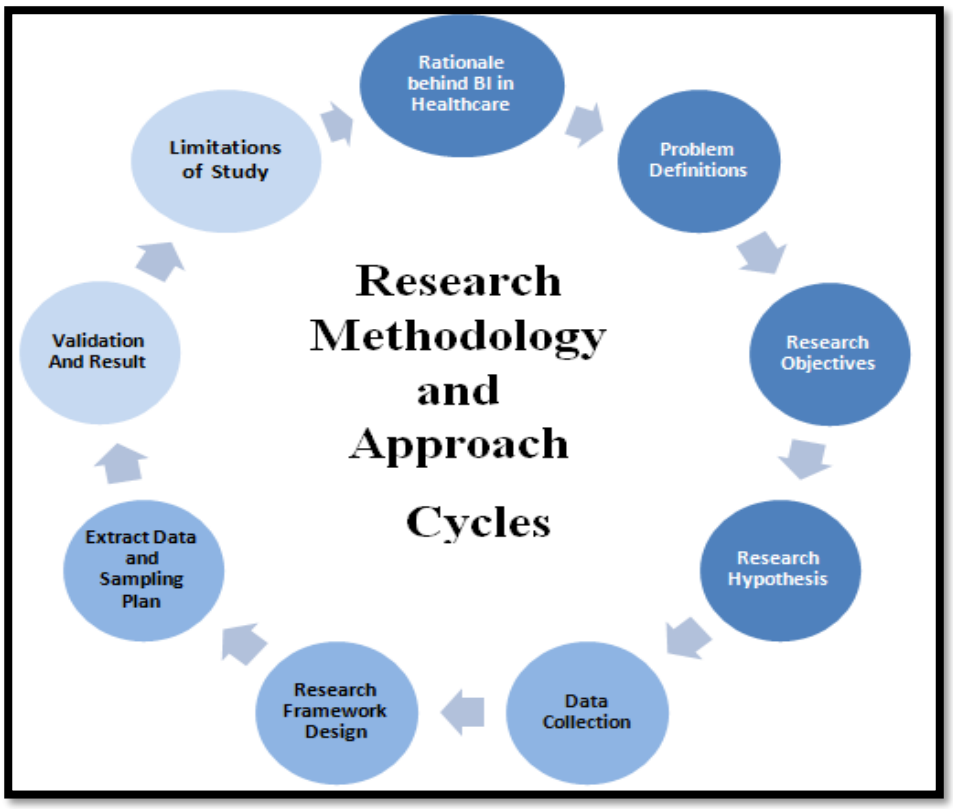

Figure 3-1 Research Methodology process

This Section explains the approach used to, first investigate the user requirements. Then study the plan technology based on the implementation of BI in the Sudanese healthcare sector, to improve informed decisions for the stakeholders participating in the decision making in this sector. To obtain a greater understanding of the dynamics of the envision of framework, the stakeholders addressed in this study were categorized as internal actors who directly interact with the Sudanese healthcare lifecycle, including patients, and hospital-related actors, such as physicians, hospital staff and manager, and external actors who are associated with the healthcare lifecycle, including the Ministry of Health, the government, the WHO and other related institutions, such as medical insurance companies, medical suppliers.

According to (Taylor, 2014) there are two types of research methodologies, quantitative and qualitative. This study will combine both quantitative and qualitative methods that have been conducted simultaneously or sequentially to understand current practices, was utilized that involves collecting, categorizing,

analyzing, and interpreting data using to support the representation of data in the healthcare lifecycle. The user requirements were gathered by systematically blending qualitative and quantitative techniques (Taylor, 2014). Qualitative techniques are appropriate to investigate many factors that require understanding behaviors, such as motivation, beliefs, experiences, views, and actions of the internal actors. Then data will be collected through the study of BI use in the literature review and the data analysis, toward refining the research objective and developing a preliminary version of the proposed model. Subsequently, the path will be laid out to validate the efficiency of proposed model.

The process to realize the research objectives are categorized into the following six main tasks. Figure:3-1 above describes an outline of the research process.

3.2 **Explore BI Technologies' Use in Healthcare Sectors**

An investigation of the implementation of BI technologies and data-driven analytics in general to aid all facets of Healthcare sectors including its assistance in decision-making and predicting. This conscientious study is lead out to confirmed and purify the research hypothesis, extract knowledge, and research recommendations to utilize in later steps.

The literature review, as detailed above in Chapter tow, is divided into three main areas:

1. Research about the use of implementation BI in healthcare domain in general.

2. Research on improving decision-making in healthcare sectors using BI.

3. Research, healthcare stakeholder's requirement and benefits for BI, specific focus on Sudan.

In this function, the goal is to realize the research objective "investigate similar experiences and best practices in attempting to reach the suitability of the envisaged application of these techniques implementing BI for healthcare sector data", including the investigation of data modelling and design technologies to select appropriate instruments to be used in later stages.

Also, another goal is covered to “gather data from these healthcare organizations and to achieve the integration” or achieve objective (2), and to initiate preliminary towards the fourth objective (4) “Proposed BI framework model”, and serve as a preliminary basis for its evaluation.

3.3 Classify Healthcare Target Group

In this task, the focus is on the exploration as well as identification of Sudanese healthcare stakeholders that currently have influence on healthcare lifecycle in Sudan. The major effort in this step concerns identifying factors and stakeholders that have a direct or indirect effect on the information life cycle of healthcare organizations, and determining the lack of information in this sector, how the data is collected and what framework was used previously, and what is needed to restructure this data and its framework, using medical data for a specific period or a specific disease to get indicators under several factors in public healthcare at a Sudanese hospital either public or private. The target group for the proposed BI framework involves.

3.3.1 Federal Ministry of Health

Represent the pinnacle, it is responsible for healthcare policy, strategic planning, coordination, and harmonization of all health actors’ actions and plans including national and international players, it is responsible for creating general healthcare report per years based on the hard and soft information it came from hospitals and medical centers either privet institutes or governmental healthcare institutes, that information at the state level, and also take direct responsibility for the organization of health in the state (Omer, 2018).

3.3.2 State Ministry of Health

The intermediate layer is the state ministries of health, they are in charge of health planning, policy-making, and implementation at the state level, and concerned mostly with policy implementation and service delivery, as is the case in the state of Khartoum, it creating summary report, content indictors of disease detected or

frequency of patients, births and deaths indicator, number and distribution of medical staff (Omer, 2018).

3.3.3 Public &Private Hospital

It is a foundation of all the information upon which to build reports, that it is a measure of performance for all services which are considered the nucleus for all health care information providers to estimate and optimize making a decision, reduce cost, get patient satisfaction. So the researcher concentrated on, and keep track of the movement of patients and their information and how to handle them and how to set prices of services and measures of patient satisfaction and how to gather information by hospital form or ministry form beside that data is un homogeneous and consistent and same format and so different methodology, and how to analyze and presentation and submit them to related authorities or state/Federal ministry. Therefore, all information and data will be applied on three hospital selected.

Three selected private hospitals in Khartoum, namely: (X) Sharg Alneel, (Y) AMC, and (Z) Aliaa hospitals, were designated as target group for the study. These three healthcare providers were selected for many reasons including the fact that they are large hospitals with many departments and deliver a wide range of medical services. Moreover, they have decent ICT infrastructure and are already relying on HMSs for their operations. This means that historical data and logs are readily available electronically for the DW implementation. Correspondingly, the cooperation capacity of the hospitals' technology departments for scientific research played a role in their selection.

Concluding, this task deals with the second objective “information life cycle and identify the healthcare stakeholders” and the third objective “Investigate environmental factors influencing the proposed BI framework”.

3.4 Identify Data and Data Gathering

The methodology analytical research, serves to identify factors that effect on healthcare and employment practices in Sudan. To achieve these objectives, this

research starts with a comprehensive exploration of literature concerning BI in general. The specific objective in this task is to determine data sources and as much quantitative historical and up-to-date data as possible, such as real data, statistical sources, annual reports, etc.

To address the research questions, many data are collected, carefully studied, preprocessed, in term of analyzed, examined, synthesized, and interpreted toward finding patterns, and generalizing results, to discover main variables and factors involved and detect inconsistencies. Then, all data sources, attributes, data types, and other characteristics are documented. During this process, conceived missing data are identified based on the research objective and possible sources are highlighted. Then, data cleansing and integration strategy can be set to enhance data quality, security, completeness, anonymity, and accuracy at the source, before, and during the ETL process. The objective is to categorize entities and attributes of the source data identified previously and start the process of creating the metadata repository to build a DW model. To take advantage of BI analytic tools, all the data from all these sources must be integrated into a single repository to make it accessible for querying and analysis. tobe ready to migration into DW should be able to derive BI knowledge. The focus of collecting data was particularly put on internal /stakeholders: in terms of representing all patients 'transactions, either clinical (medical?) or administrative, in three private hospitals in Khartoum: (X) ShargNeel Hospital, (Y) AMC Hospital, and (Z) Aliaa Hospital. The data collected in these hospitals involve, for example, the total number of patients treated by the hospital, the number of patients who received specialized treatment in a hospital including the price of the treatment, demographic data about physicians and patients such as gender, age, living location. Table 6-1 provides an overview of the specialized treatments by the hospital (referred to as X, Y, and Z, respectively) as well as the frequency of use of treatments offered in the period from June 2012 to May 2018.)

Data gathering from several sources can be summarized in three types of institutions:

- Government institutions (Ministry of health) summarize data from government institutions and private sector institutions and produce a

statistical report based on their own indicators that assist planning and development.

- Private institutions, some of which are profitable and other services provide the health service, and the researcher focus of attention for the researchers because it has huge data and also governmental institute get data and its information from there.
- Institutions that have an indirect relationship with the health sector, whether insurance companies or international organizations all of them not providing healthcare services put its involved direct or indirect either be paid to get that services to its clients or reduce the risk of a particular disease by funding the delivering of treatment service to reduce the spread of it, but on this Thiess we cannot focus on this data.

Then we can show in the flow table the type of data that is gathered with its format and content of it besides what is observations of researcher and its comments to that data.

Table 3-1 Data Gathering Type

Data Type	**From**	**Content**
Excel File	Ministry of health	Statistical Data Analysis from all hospital in Sudan with Details and how it gathering from its source (state, hospital, localities),the draft framework that data gathered by it .and method for collection information and who to analysis it.
Hardcopy + document file	WHO	Statistical data analysis from ministry, project funding and statistical of covered by WHO Activities to combat the endemic and communicable diseases
SQL server + Excel file+.doc	ShargNeel Hospital	Demographic patient data , and what the service that deliver and service price package, frequencies on clinics and statistics operations and tests , emergency ,service time live, death and porn statistical

Oracle	AMC Hospital	Demographic patient data , and what the service that deliver and what the disease
SQL server + Excel	Aliaa hospital	Demographic patient Data , and what the service that deliver and what the disease, frequencies on clinics and statistics operations and tests , emergency , list price of service
Hardcopy + Excel file	National Health Insurance	Statistical data for population covered by then and its service

In this task, serves the treatment of the second research objective (2) “Identify information life cycle of Sudanese’s healthcare organizations” and the third objective (3) “terms of structure, homogeneous, format and integration of data” are addressed by gather data, and to initiate preliminary towards the fourth objective (4) “Proposed BI framework model”.

3.5 Data Preprocessing and Migration

The preparation data intended to make it homogeneous and consistent, is one of the most difficult processes, including data collection. So in this part we followed several steps, re-dividing data according to sections, knowing that there is a difference in some names that are in the original data. But the difference is according to the hospital's perspective specific in the naming, so the researcher had to seek the help of some doctors to clarify the medical terms, to unify them between hospitals before the process of transferring them to DW model as migration information, to be ready to help in decision-making.

Each member of the target group utilizes their HMS in different capacity and with a different approach. Strict data security, privacy and integration procedures were applied when designing the ETL strategy. First, the medical data, that includes a listing of all the clinical and diagnostic services provided and their cost, together with patients’ care and demographic data, such as, treatment data per date\time, department, and cost. The second category is administrative data, including financial data, such as departmental revenue and expenses, hospital revenue and expenses, etc. Also included in the administrative data is the human resource data, such as, the number of staff per department, departments’ turnover, as well as logistics data.

The DW data model was designed, developed and implemented using Microsoft SQL server. The data collected for the BI implementation was manipulated using the developed ETL strategy and then migrated and inserted into the DW, to validation the efficiency of framework models it must be containing a flowing aspect:

- **Based on time management and service converge Case Study**:

1. Demographics data for patients with its medical record numbers(MRN).
2. Services that providing by the healthcare institutes either medical services or pharmaceutical drugs and also physicians interview. and take into account any services it must be belong to department or providing through it.
3. Institutes information either its name and locations to determine belonging to what statues.
4. Institutes of insurance company the patients related with it or shall paid on behalf of patients.
5. Information of users that providing that services with its Id and name.
6. Services prices for any customer.
7. Transaction of processing when providing that service including its date and its time that summarize by where and when and how many?

- **Based on staff management Case Study:**

1. Physicians Information and its jobs and its departments
2. Information about turnover of staff and its type of reason of separation or left its jobs.
3. Revenue and expenses information for any department in the institutes.

Then we can say the preprocessing and extract data based on what data we need to achieve our goals based on the objectives and hypothesis, is passed through several stages:

1. Analyze the current status of any institutes and what information is shared among the medical field partners.
2. Determine the data that we needed to be translated for information by using BI tools to help the stakeholders to make a decision, taking into account the concept of systems analysis and design.
3. Collect raw data and then process and re-structure, for any institutes individually in separate DB, taking into account the common traits between

them, with distributed database systems concept when creating a model to serve external actors or stakeholders if we need to evaluate and make a decision that related by general healthcare situation.

4. Testing and validating the consistency of data to prepare using BI tools to visualize them through reports, graphs, and (KPIs), using analytical processing tools.

5. Determined the tool requirements in healthcare environments that mention to it on the BI Tools paragraph and select ETL, and Extract, because the BI tool must enable established a connection to many databases so that it is possible to integrate information from variant data sources or repository that determine in this thesis by three DB. There are tools where the only possibility of connection is inherent to data visualization, others in which the connection can be made via the ETL process, and via data display, and, lastly, those in which the connection is made only via the ETL process. In healthcare institutes, this is also a key feature because, normally, these institutes may have interoperable application systems, and it is common to have different databases with medical information if it is. Thus, to facilitate the construction of the data warehouse (DW), we must choose a specific tool for the construction of the DW and, subsequently, a tool of BI is used to create OLAP cubes to visualize performance indicators. also Real-time it's very important in the healthcare sectors especially in an emergency case, and also the solutions (QlikView, Palo, Jaspersoft, Tableau, Spago, and Pentaho) were selected to be explored tested the framework models but useful tool is MSSBI because very flexible to support distributed Database system.(Brandão et al., 2016, Wang et al., 2018a).

In this task, the second research objective (3) “terms of structure, homogeneous, format and integration of data”, it was covered, and to initiate preliminary towards the fourth objective (4) “Proposed BI framework model”.

3.6 Design BI Model

Data models describe, from both logical and physical perspectives, the layout and properties of the data structures designed to store data in the operational and

analytical environments. The goal of the model is to facilitate the conclusion of qualitative results deriving from the quantitative, collected and manipulation in the previous tasks, revealing characteristic information leading to affirm the research objectives. So they crystallized the idea from data model concepts with its three different types, Conceptual Data Model for defines and explain WHAT the system contains. Logical to Defines and explain HOW the system should be implemented regardless of the DBMS. Physical Data Model to describes HOW the system will be implemented using a specific DBMS system, therefor after designing the conceptual model of the database using Entity-Relationship (E-R) diagram, we need to convert the conceptual model into the relational model that can be implemented using any RDMBS languages like Oracle SQL, My SQL, etc.

Since all input data will be coming from healthcare operational either medical or administrative neuter in layer (A) in the proposed BI framework, then extraction useful data to layer (B) DW, to be ready to executing any explanation queries through layer (C) that content the BI technologies, to support the level of information knowledge in layer (D), in term of providing the healthcare stakeholders with the information and knowledge to making accurate decision in time manure, that leads to improve the healthcare sectors and improve the services providers in Sudan.

In this task were addressed toward the conveyance of an effective BI model and serve as a preliminary basis for its healthcare sectors, the second research objective (4) “Proposed a framework that optimizing Sudanese’s healthcare sectors”, and to initiate preliminary towards the fourth objective (5) “The efficiency of outcomes of the proposed framework that can help healthcare stakeholders in decision making”.

3.7 Validate Framework

To validate the efficiency of model from the perspective of time and service and staff management. The intent is to measure various perspectives, take into account data integration, certainty, trust, and security of patient information, to help make better organizational decisions and enhance efficiency, data access to statistics, and new knowledge to improve the healthcare quality, safety, financial performance, reduce risks caused by an environmental source, ensure the quality of the care as well as the patient security, reduce costs.

Content analysis methods resulted in the identification of many factors influencing BI implementations in healthcare. Exploratory interviews with hospital administrators and patients at the target group helped in highlighting and prioritizing these identified factors. KPIs, possible queries and information dashboard were created based on the stakeholders' feedback to study the possible correlation between these factors, their significance and thus validate the efficiency of framework. To facilitate the impending analysis, these recognized factors are grouped into the following three interrelated categories:

3.7.1 Provider Management

This group includes many factors prioritized by hospitals administrators in their quest for the delivery of outstanding quality services. They are divided into three subgroups, namely, patients' and staff satisfaction and financial factors. As previously explained, patients' satisfaction is the target of healthcare service providers. While human resource management reflects directly on the services they deliver, reducing operational cost and increasing revenue. It also indirectly affects patients' satisfaction and increases patients' visits frequency. Major factors in this subgroup are staff turnover, staff training, and motivation.

For the second subgroup, i.e., financial factors, healthcare providers strive to strike a delicate balance between increasing their revenue and reducing cost on one hand, and improving the quality and availability of their services on the other. Consequently, providers monitor hospital units' revenue separately and collectively. An example of this balancing act, is that sometimes providers opt to operate a low return service or department for the sake of patients' connivance. Since the integration of medical services at the same location leads to patients' satisfaction. The BI model enables capturing this information through the appropriate KPIs and presenting it in the information dashboard.

3.7.2 Service Management

This group of factors is composed of medical service availability and service cost. As explained in the previous group of provider management factors, the availability of all clinical diagnostics, tests, and treatment under one roof is vital for patients' satisfaction. Availability and cost are essential factors from the perspective of many

stakeholders including patients, regulators, insurance companies, and hospital administrators. For example, health insurance companies use this information to negotiate better contracts with providers, uses it to plan its regional and national service coverage maps, patient's use it to choose between providers, etc.

These vital factors play a major role in reducing the cost of treatment while maintaining quality. The BI model through the appropriate dashboards enables stakeholders to explore different aspects of services availability and affordability and draw their own conclusions.

3.7.3 Time Management

Managing time is critical for healthcare providers as well as for patients. There is an inverse relation between patients' frequency and services' availability. Without time management, this correlation leads to extended waiting and service times, and has a negative impact on patients' satisfaction and ultimately providers' revenue. To mitigate this situation, providers plan for each service station as an independent unit and provide adequate staff training. They also extend ample logistics services support, either implicit as hospital environment or explicit such as attention, care, and attitude toward patients. The BI model through the appropriate dashboard enables managing and monitoring all these factors.

3.7.4 Knowledge

One of the method to confirm the efficiency of the proposed model, and the extent of its contribution to improving the healthcare sector in Sudan, it is the type and nature of the knowledge transformed from the information. Therefore, we find that the knowledge extracted in this thesis uses data mining through Rabid Miner techniques is used through various algorithm is summarized on (Clustering, predicting and analyzing using Generalized Linear Models, Deep Learning, Decision Tree and also used Naïve Bayes approach) all of them to enhance the healthcare sector by providing the decision –maker by the knowledge's.

In particular, this task covers the analysis of the data integration and preprocessing arrived at in the structural models and data gathering review which is the main focus of the previous task, the second research objective (3) "terms of structure, homogeneous, format

and integration of data", and to initiate preliminary towards the fourth objective (4) "Proposed BI framework model".

1.1 Analyze Findings

This research hypothesizes that utilizing the envisioned BI framework will enhance the healthcare sectors and provide their decision-maker by the information for enhance and planning.

As discussed in the previous section. The Sudanese health care information needs a new framework for enhancing healthcare services, and information either on the hospital or ministry of state, and then you can implement to get or objective goal. after gathering data from various institutes with a different format and unstructured data, it suffers many of lack in:

1. Inaccuracy of information obtained from areas of service.
2. Lack of transparency, and delay of reported.
3. Data analysis method is based system attic can refer to him easily.
4. Unavailability of computer systems in many institutions, departments or sections, making it difficult to rapid decision-making process based on structured information.
5. There is certain information gathered by reverse way.
6. The method of gathering information cannot ascertain whether as general indicators of health in the whole country because it ignores many of the data in many departments because focus to emergency department of obstetrics and gynecology, and also the proportion of the collection of information model focuses on specific diseases and there is a constantly updated. It also ignores the specific aspects of patient satisfaction scores and reduce the cost and also indicator of stability competencies.
7. There are many medical establishments does not have systems adopt its information on the registration papers, so be inaccurate in its process and its report to stakeholder and its organization its self.
8. The data base design and structure and type of information is different form hospital to other based on its software if exist. Which makes it shows a lack of homogeneity of the data with other institutions.

For this purpose, multiple statistical analysis techniques will be applied to analyze the results of the surveys including simple descriptive analysis to identify participants' characteristics and analytical to investigate the relationship between different variables as well as. An appropriate statistical analysis tool will be selected and utilized. With regards to the evaluation the efficiency of framework in tow concepts, by results and dashboard obtained by applying modeling rules and imaging model, and also by the table of information that reflect knowledge for healthcare decision makers to enhance this sectors, as services providers.

In this task, serves the treatment of the third research objective (3) "Approve the suitability of the implementing BI for healthcare in the Sudan", and covered the fourth objective (4) "Optimizing Sudanese's healthcare sectors", The main contribution for the research, this task covered the fifth and final objective (5) "Validate the efficiency of outcomes of the proposed framework that can help healthcare stakeholders in decision making", and sufficiently contributes, for implementing BI framework efficiency validation approach explained above.

CHAPTER IV

CHAPTER IV

PROPOSED SOLUTION FRAMEWORK

4.1 Overview

We dedicate this chapter of the thesis to explaining our contribution, namely the Sudanese healthcare model and framework proposal for the implementation of the BI in healthcare sectors improving informed decisions, for any stakeholder that related by Sudanese healthcare sectors whether represented in the government or institutions and its shareholders or managerial of it, on the other side the patients he needs too many decisions in the trade-offs between service providers based on several criteria or aspect.

From the above point of view, and information gathered from the institutions of healthcare sector that visited by the researcher, whether to get data or know how to make decisions based on the information available for them either statistical or oral and visual, all of then let the researcher suggest framework models base on conceptual of data warehouse that containing all of important data that influential when to make decision based on information, for all participants in the health sector cycle begin from the patient to healthcare institutions, ministries of health, pharmaceutical suppliers, medical consumables and decision-makers in the country, all of this data selected from several systems in healthcare institutes , in order to be stored in a central database (DW) containing all institutional transactions in the patient's medical file and services provided to patients at their prices and time of service , taking into account type of data or software that appalling in any healthcare institutes from perspective of heterogeneity and compatibility in the structuring of the data and the names of services and so variation generated by the several of HIS software systems used also.

The framework model designed base on the conceptual of DW of Sudanese healthcare and medical sectors and data related to representing the ministry of health and its healthcare institutes (hospital or medical centers ..etc.), with its departments or its units that delivered the services in the institutes, and what services belong to that units and whose physician work on it and what is the price of that services and what is the expenses and revenues for any institutes, and number and type of staff

on it also, and demographic data of information for any patients that get services in any institutes with its price and its delivered time and who are users providers. on the other side, the data of medical insurance company, which provides health insurance services to patients. and data of medical suppliers, who supply medicines and medical consumables to the company as needed, with its transactions, that create and content concept of DW.

The design of the DW Framework passed through several stages are divided into the following:

4.2 Framework Architecture

On this section the stage of create Sudanese healthcare framework models, to represent attributes of an entity, and the relationships in the conceptual data model that describe the transaction patients cycle in the healthcare sectors processes, to achieve the framework thought logical data models concept.

4.2.1 Conceptual Data Model

The conceptual data model is one of type data modeling to describe the purpose is to organize, scope, and define business concepts and rules. the main objective of this model is to set the entities, their attributes, and their relationships. In this data modeling level, there is barely any detail available of the healthcare actual database structure.

After gathering data by the researcher to determine the information life cycle of healthcare organizations, and determining the lack of information in this sector, how the data is collected and what framework was used previously, and what is needed to restructure from this data and its framework, using medical data for a specific period or for a specific disease to get indicators under several factors in public healthcare at a Sudanese hospital. and we can imagine the new framework models looks at (Figure (4-1): Sudanese healthcare conceptual data model) to establish the entities to represent a real-world thing, their attributes to identify characteristics or properties of an entity, and their relationships that represent characteristics or properties of an entity, but at the conceptual data modeling level, there is hardly any detail available of the actual Database structure.

To implement BI in the Sudanese health care sector to get restructure healthcare data to obtain it in a useful format that represents by conceptual data models as the following table. to achieve a good quality of service and patient satisfaction with cost reduction. and extracting information from huge data, and enhancing strategic decisions by using BI tools.

Table 4- 1: Entities of Conceptual Data Model

Entities	Type	Other Information and Notes
States Ministry	Table	Represent the Sudan federal states with its relationship between the ministry of health
Hospital	Table	The table represents the collection of hospitals understudy after structured data
Department	Table	The table represents the collection of Department or units that delivered the services in Sudanese healthcare after structured data
Department - Hospital	Table	Represent what the Department or clinical units specialists that available on any hospital
Services	Table	Content all the services at Sudanese healthcare Sectors providing in any hospital.
Hospital - Department - Services	Table	Content all the services at Sudanese healthcare Sectors providing in any hospital taking into account availability or services coverage, and distinguish between them here
Users	Table	All User Using the software and doing any thinks either entering data or extract report (Stakeholders)
Staff	Table	All User Using the software and doing any thinks either entering data or extract report (Stakeholders) either employees or consultants outsource.
Staff Turnover	Table	Table Content a Collection of employees separation information date and types and reasons
Insurance Company	Table	Table explorer the medical insurance company that pied for the patients that belong to its services
Patients Transaction Hospital	Table	Table represent all services delivered to patients and where and when and how many and how is request it and who is done by
Patients	Table	Table content patients demographic data who is insurance company belong to it or bayed by himself
Hospital-Revenue-Expenses	Table	The table represents all transaction-related by financial either by the patient's services cost or administrative expenses or services Revenue or suppliers bills either consumables or assets or drugs

Entities	Type	Other Information and Notes
Suppliers	Table	Content all the suppliers work on the Sudanese healthcare Sectors providing hospitals by the consumables or assets or drugs ..act.
Hospitals-Suppliers -Trans	Table	Content all the transaction of providing hospitals by the consumables or assets or drugs ..etc. and when and what is it and how much and how many, and what is the type of it

Table 4- 1 represent the entities of concept of DW to create the Sudanese healthcare conceptual data model, that entities is indicate to the analysis and design process to achieve right implementation needs to required information from all stakeholders needs to be handle, and extracting information from huge data.

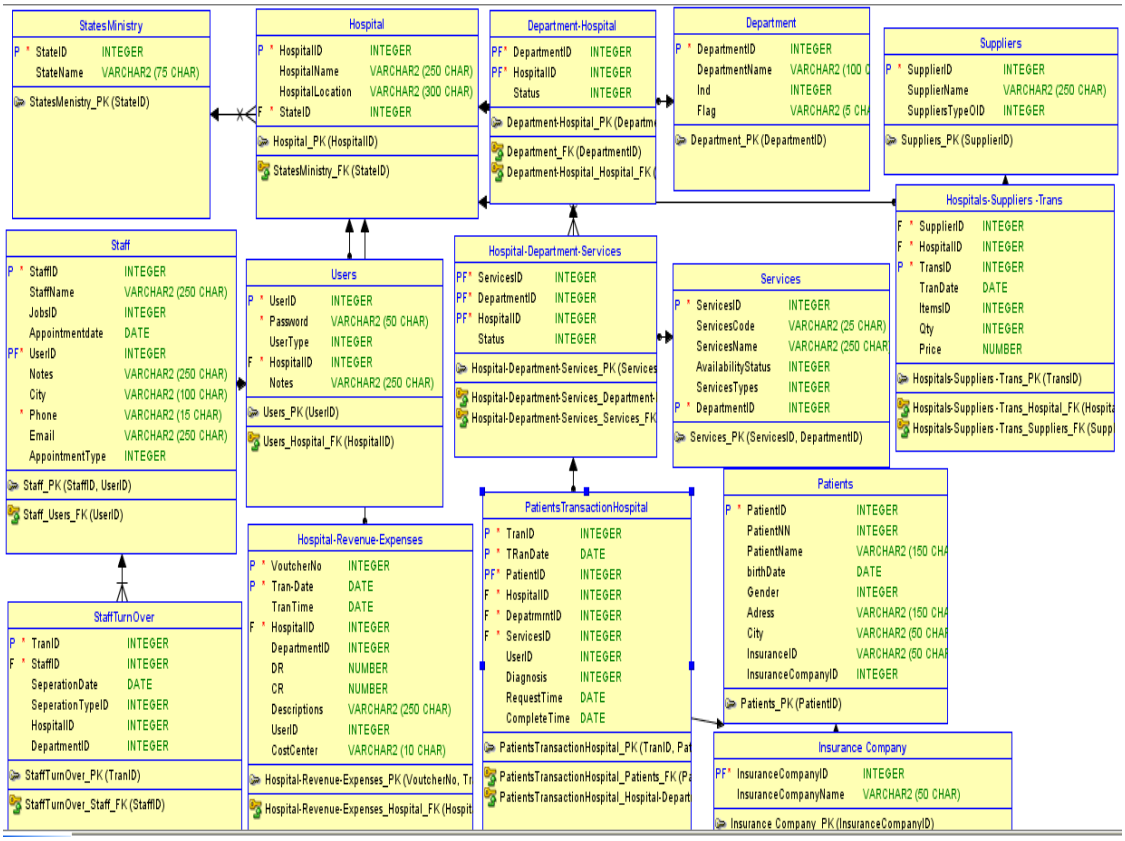

Figure 4-1 Conceptual Data Model

The structure of the conceptual data model after represent at the entities and table above and with its attributes in Figure (4-1) (Sudanese healthcare conceptual data model by its attributes). then we can divide the conceptual framework models from

the perspective of transaction and relationship between stakeholders into four layers, include shareholders who are directly or indirectly involved in the process of the life cycle of health care information upon which decisions by implementing BI, that serves as a subject of the thesis and optimal applicable to achieve the goals and assumptions formulated in thesis. The framework models reflect the conceptual data model from perspective of the lifecycle of healthcare data in Sudan, that divided for many layers, the main layers that data will be collected from them and created data set to implement and validate the efficiency of framework upon it is first layers. Which deals directly with patients and their information (names, age, their residence ...., etc.) and medical departments that have all visits, and what are the tests that have for them and what are their results and what the diagnosis and the treatments that are given to them. All this information answer that questions must be found in a database for any hospital or health center or clinic use applying (EMR or EHR) as software to support a full history of a patient in any place by using integrating data. that software it must be contained a record of all patient processing, done by any users either receptionists or physicians, or any user using that software to do their jobs, and so it must be taken into account the time of processing to determine the duration of time for patient spent until receiving service, as well as element privacy and confidentiality of the patient information at different levels, to ensure the confidentiality of patient data and preserve their privacy. The concept of the model is based on the data set that creates after gathering from level zero (hospital or health center or clinic) and reformat and containing patient information whether the demographic date of a patient or health record diagnosis, treatment, the result of tested, medical report, that data collected from hospitals, health centers, and clinics systems and other Portal can be designed according to the model shown in Figure (4-1), which is to describe the movement of patients or patient's pathway to achieving medical services to them, and its relationship with the participants in the procedural process for each patient.

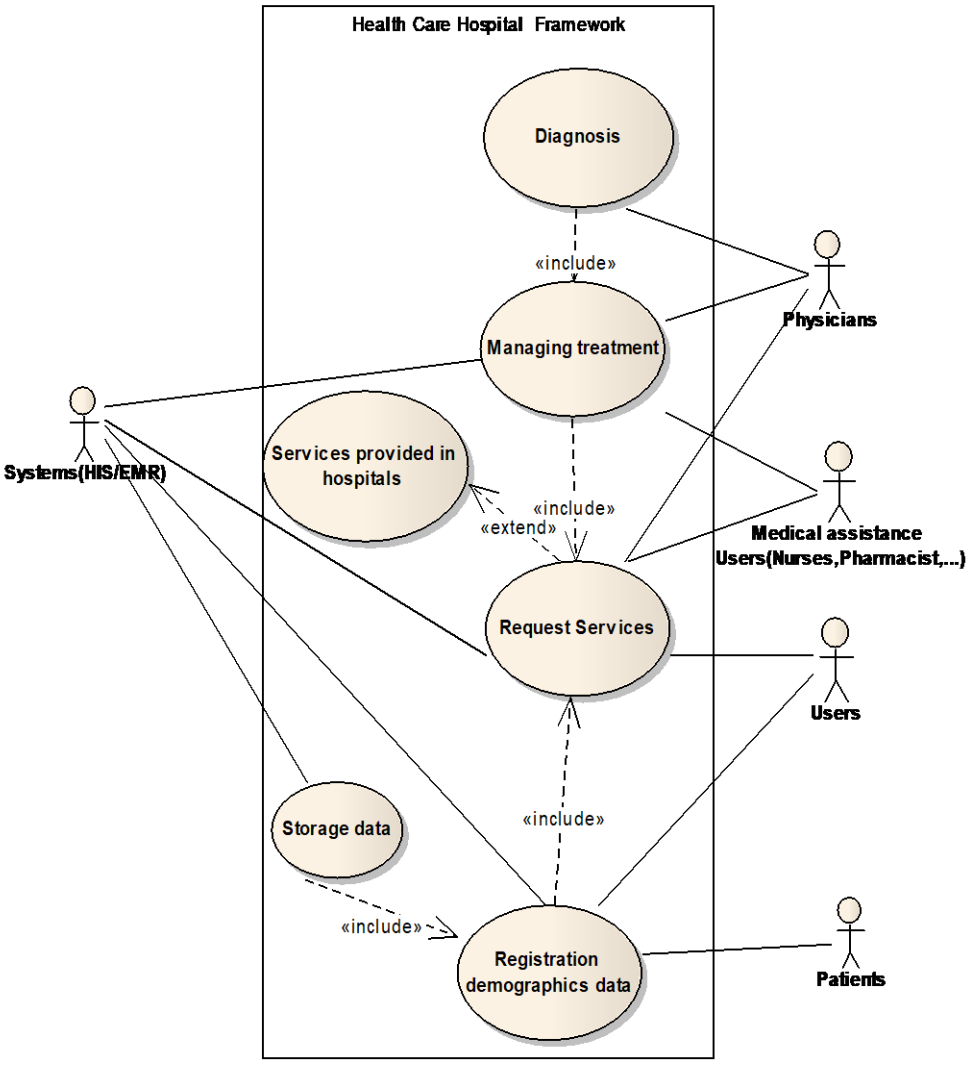

Figure 4-2 Sudanese Healthcare Patients Cycle

The main issues of the Figure (4-2) explain the documentary cycle of patient activity within any medical institution (hospital, clinic, health center), intended for receiving medical services, whether available or otherwise. Also every patient's activity and its services that have been delivered must be recorded and stored in the database through the patients' medical records system (EMR or EHR).

We can describe it the patients determined what the service need to get it and then chose what hospitals that service available on it, and compare between them from destination point, what is near for them and what the best services, cheapest cost, and good service quality, good care and timeless of waiting to get it .and when the patient comes to the hospital after choosing what the pest comparative medical services firstly need to register to get service by meeting the physician or specialist of either surgeon or orthopedic or any department that available, by unique medical

record number (MRN or EMR), that contain demographic data of the patient and record the medical history of the patient and its family, to help the physician to diagnosis and treatment, that registered by the nurse or physician itself and then requested investigation if he needs to complete the diagnosis processer. all of this process with conceptual Framework concerned with time and quality of service to get patient satisfaction indicator, to get the result of the implementation of BI by using the Sudanese healthcare framework.

This is first a requirement needed for BI implementation in the Sudanese healthcare industry because the BI needs at the phase of identifying and preparing data. That data must be restructured and reformat in extract data set to preparation first step to implementing BI system in the Sudanese healthcare industry to extract main health indicators, Whether on the level of the service provider (Hospitals/Medical Centers/ Doctor s Clinics) or at the shareholder level (Managers and/ Ministry).

In the context of BI, technology can be seen as an enabler for storing, analyzing, visualizing, and giving access to a great amount of data. For this objective, a wide range of expert systems, OLAP and data mining tools are used coevally in a BI system. On the other hand, technology is required to provide an integrated view of both, internal and external data (for example through a data warehouse). It is therefore the base for BI.

Figure (4-3) clarifies the relationships of processes, actors, information, and technology for the BI context in the healthcare sector.

Table 4- 2: Sudanese Healthcare Patients Cycle Information

Actors	Descriptions
Physicians	Refer to doctors and specialists who deal with the medical system and diagnoses the condition of patients and policies for treatment of them.
Medical Insurance	This refers to institutions that carry out medical insurance for individuals or employees of the government sector or private sectors, which pay the cost of treatments for patients on their behalf according to the policy of each insurance institutions.

Users	Users who feed the systems information include the patients' demographic data and medical services available or covered by that hospital that is required for each patient and also includes receptionists, nursing staff, and sometimes doctors themselves.
Patients	They are patients who receive treatment or get any services to converge within the health institutions.
Systems (HIS/EMR)	It is a medical system used within the health institution and performs all operations on them and provide detailed information to help in deciding to by owners or Managers of the medical institution, according to the BI system concept.

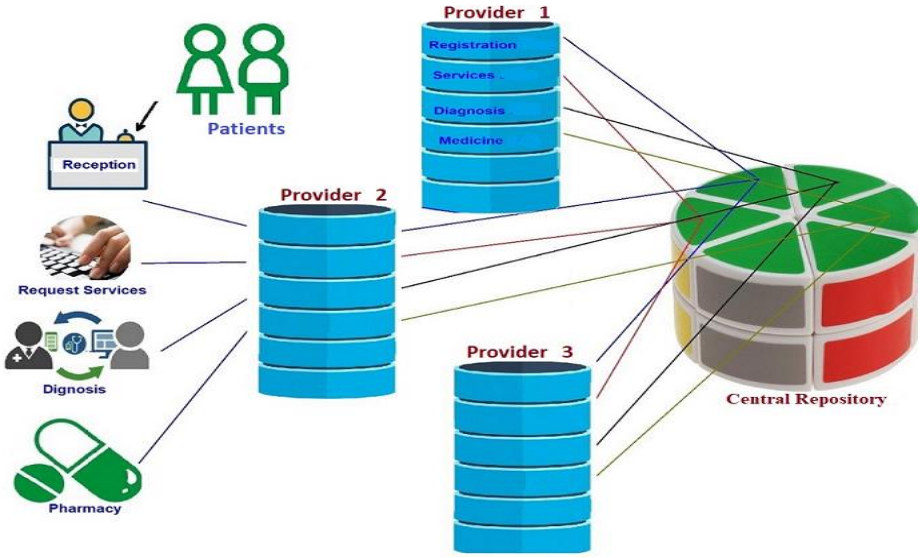

Figure 4-3 Patients' information lifecycle

Fig. 4-3 and Table 4-2 illustrate the exiting patients' information flow. It shows the registration, services, diagnosis and therapeutic information stored in each local provider's databases. As will be explained in the next section, the proposed framework integrates select information extracted from these local databases into a common repository.

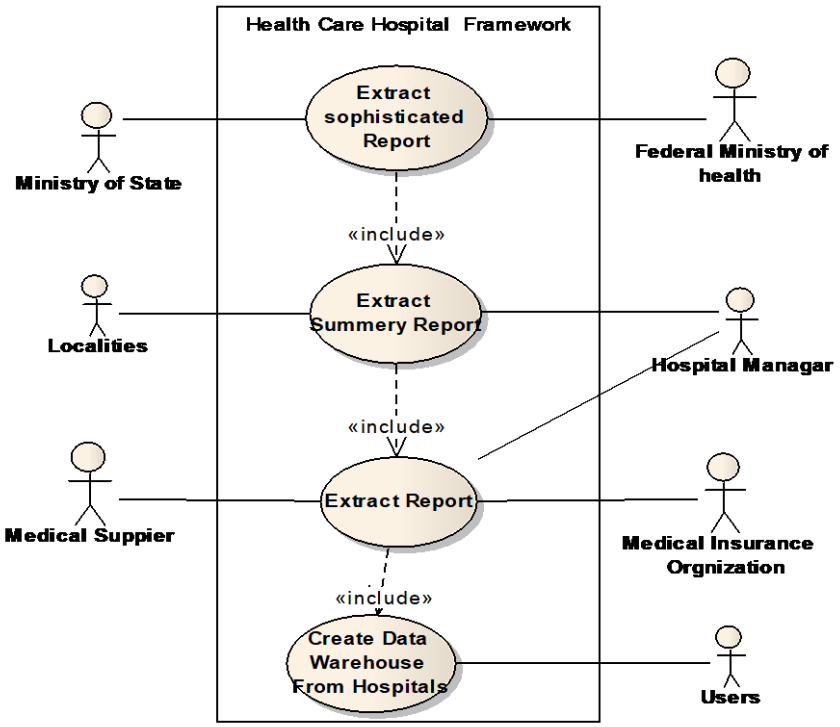

Figure 4-4 Sudanese Healthcare Processes Relationships

To get the benefit of using technology in the healthcare sector, to achieve the specific objectives of health institutions to reduce the cost and get the satisfaction of patients and health care delivery better service and achieve material gains and good reputation of the institution, and that the medical establishment level including healthcare actors as lustrate at Fig 4-4. At the level of the state and companies related to the medical field, whether suppliers or provide medical insurance service, all of them needs to indicators like frequency of department per day or month and the operation in a specific period or the disease in area or season, help them decide without going into the processes that take place for patients details, we find one of the main inserts of the federal ministry of health need to reading indicators of health state at the country level and what are the most common disease. At any age and in any areas prone to them. And compare the performance of the medical activity by the number of a patient registered to the specific clinical unit in the hospital or high frequency of investigation its result is positive, and what most common diseases in area or regions or hospitals and regions and any medical services by deficiencies in the designated area, and a lot of reports and Indicators that help in decision-making. All of this significant indicator became appear when using and implementing BI and

the new BI Framework in the Sudanese health care sector and achieve goal of this thesis.

Table 4- 3: Sudanese Healthcare Relationships Discription

Actors	Descriptions
Federal Ministry	The health system in Sudan is run across three federal, state, and local levels. The federal ministry represents the spearhead of the health system. Each of the concerned bodies reports to it, to set the general health policy in the country.
Ministry of state	The central system is the management of the health system according to the country's policy.
Ministry of localities	This last level of health care systems and all of the hospitals or health care center Belong and report to this ministry and also the implementation of national/state policies and service delivery, based on the primary healthcare approach.
Hospitals Managers	The directors or managers or owners of healthcare organizations are involved in the health sector and those who build their decisions directly from information that extracting by BI to support our decisions.
Medical Insurance Organization	This refers to institutions that carry out medical insurance for individuals or employees of the government sector or private sectors, which pay the cost of treatments for patients on their behalf according to the policy of each insurance institution. it needs information to lay down their policies and future decisions.
Medical Suppliers	They are the suppliers of medical equipment, medical consumables, and medicines. Their need lies in the information on which to build the marketing and distribution process and to establish clear policies based on information obtained through the BI system.
Users	Are the users who feed the information, which in turn transforms it into a repository of data for analysis and analysis to help make the right decision at the right time.

4.2.2 Create Logical Data Model

To create a logical data model describes the data of Sudanese healthcare framework models in as much detail as possible to describe how to merging between distributed systems database that gathering from three hospitals to enhance the objective of implementation of BI and its tools in the healthcare sector to achieve our objective of this thesis, concerning how they will be physically implemented in the database, includes all entities of Sudanese healthcare Data Models(SHCDM) and relationships among them, and all attributes for each entity are specified that represent in Figure (4-4).and the primary key for each entity is specified, with its foreign keys (keys identifying the relationship between different entities) are specified. taking into account the steps for designing the logical data model are as specify primary keys for all entities and its relationships and its attributes.

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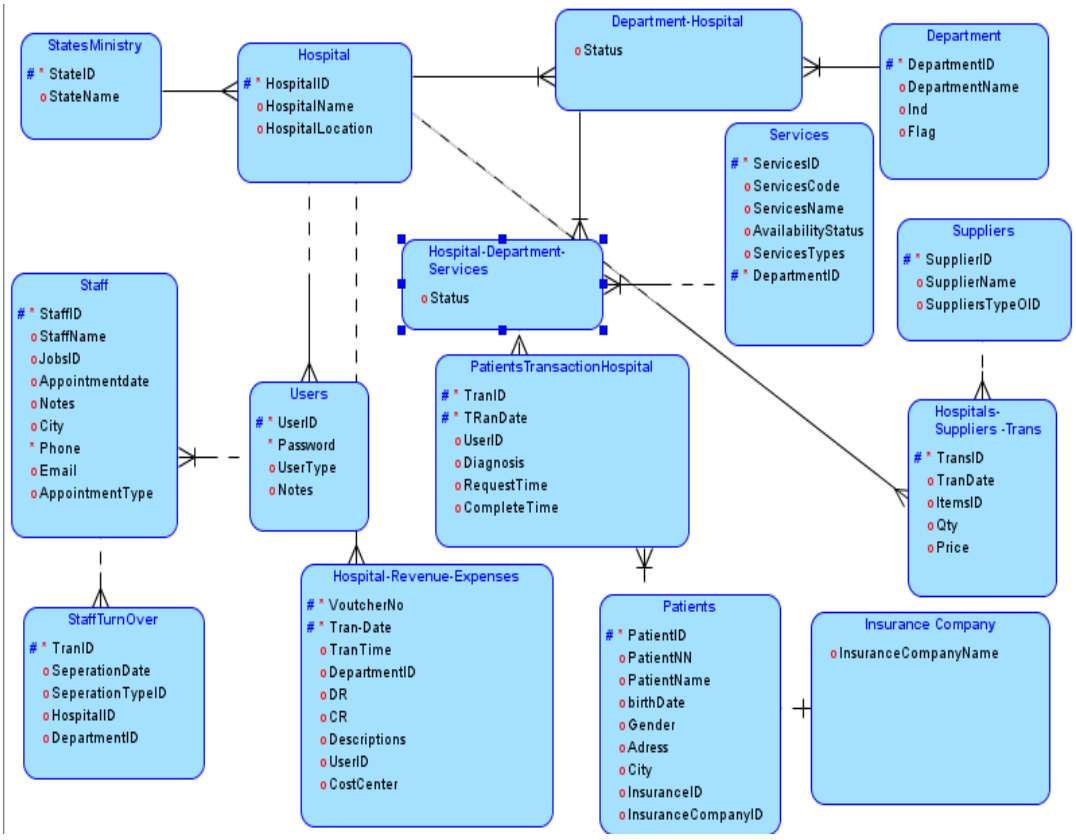


Figure 4-5 Logical model

Therefore, the objective of this thesis analyses the model contains the processes that took place in medical institutions through which to obtain the required indicators reports, including time management service covered patient satisfaction and also

employee job satisfaction and create competition between health care provider's services, to help make an informed decision.

As in the logical model in Figure (4-5), which is inserted operational summary enjoyment and data collected from health institutions and save it in a new format and restructured as a new database or data set to test the format and validate the efficiency of BI framework and get the results. It represented the by logical model the fact table and dimensions table in Table (4-5), by determine the and merge the many medical records of the patient or the frequency of medical unit from many hospitals to get wide indicator, and also daisies or investigations or diagnosis using that table showing in figure (4-5) tables on of the patient demographic information and insurance company that covers medical service cost for the patient, and that service it must be determined where it takes at what hospital and in where region or states and what that service delivered for that patient and how is doctor diagnosis this case and when and how many it coasted. all of this we can showing into the logical model in figure (4-5) or show describe of it in description table of logical model entities attribute as flowing table:

Table 4- 4: Entities of Logical Models

Entities	Logical Models Entities attributes
StatesMinistry	StateID INTEGER NOT NULL , StateNameVARCHAR2 (75 CHAR)
Hospital	HospitalID INTEGER NOT NULL , HospitalName VARCHAR2 (250 CHAR) , HospitalLocation VARCHAR2 (300 CHAR) , StatesMinistry_StateID INTEGER NOT NULL
Department	DepartmentID INTEGER NOT NULL , DepartmentName VARCHAR2 (100 CHAR) , Ind INTEGER , Flag VARCHAR2 (5 CHAR)
Department - Hospital	DepartmentID INTEGER NOT NULL , HospitalID INTEGER NOT NULL , Status INTEGER
Services	ServicesID INTEGER NOT NULL , ServicesCode VARCHAR2 (25 CHAR) , ServicesName VARCHAR2 (250 CHAR) , AvailabilityStatus INTEGER , ServicesTypes INTEGER , DepartmentID INTEGER NOT NULL

Entities	Logical Models Entities attributes
Hospital - Department - Services	ServicesID INTEGER NOT NULL , DepartmentID INTEGER NOT NULL , HospitalID INTEGER NOT NULL , Status INTEGER
Users	UserID INTEGER NOT NULL , Password VARCHAR2 (50 CHAR) NOT NULL , UserType INTEGER , Hospital_HospitalID INTEGER NOT NULL ,
Staff	StaffID INTEGER NOT NULL , StaffName VARCHAR2 (250 CHAR) , JobsID INTEGER , Appointmentdate DATE , Users_UserID INTEGER NOT NULL , Notes VARCHAR2 (250 CHAR) , City VARCHAR2 (100 CHAR) , Phone VARCHAR2 (15 CHAR) NOT NULL , Email VARCHAR2 (250 CHAR) , AppointmentType INTEGER
Staff Turnover	TranID INTEGER NOT NULL , Staff_UserID INTEGER NOT NULL , SeperationDate DATE , SeperationTypeID INTEGER , HospitalID INTEGER , DepartmentID INTEGER , StaffID1 INTEGER NOT NULL
Insurance Company	Patients_PatientID INTEGER NOT NULL , InsuranceCompanyName VARCHAR2 (50 CHAR)
Patients Transaction Hospital	TranID INTEGER NOT NULL , TRanDate DATE NOT NULL , Patients_PatientID INTEGER NOT NULL , UserID INTEGER , Diagnosis INTEGER , RequestTime DATE , CompleteTime DATE , DepartmentID INTEGER NOT NULL
Patients	PatientID INTEGER NOT NULL , PatientNN INTEGER , PatientName VARCHAR2 (150 CHAR) , birthDate DATE , Gender INTEGER , Adress VARCHAR2 (150 CHAR) , City VARCHAR2 (50 CHAR) , InsuranceID VARCHAR2 (50 CHAR) , InsuranceCompanyID INTEGER

Entities	Logical Models Entities attributes
Hospital-Revenue-Expenses	VoutcherNo INTEGER NOT NULL , "Tran-Date" DATE NOT NULL , TranTime DATE , Hospital_HospitalID INTEGER NOT NULL , DepartmentID INTEGER , DR NUMBER , CR NUMBER , Descriptions VARCHAR2 (250 CHAR) , UserID INTEGER , CostCenter VARCHAR2 (10 CHAR)
Suppliers	SupplierID INTEGER NOT NULL , SupplierName VARCHAR2 (250 CHAR) , SuppliersTypeOID INTEGER
Hospitals-Suppliers -Trans	Suppliers_SupplierID INTEGER NOT NULL , Hospital_HospitalID INTEGER NOT NULL , TransID INTEGER NOT NULL , TranDate DATE , ItemsID INTEGER , Qty INTEGER , Price NUMBER

Comparing the Sudanese healthcare logical data model shown above with the conceptual data model diagram that shown also above, we see the main differences between the two:

- In a logical data model explorer entities' primary keys are present, whereas, in a conceptual data model, no primary key is shown.
- In a logical data model, all attributes are specified within an entity. No attributes are specified in a conceptual data model.
- Relationships between entities are specified using primary keys and foreign keys in a logical data model. In a conceptual data model, the relationships are simply stated, not specified, so we simply know that two entities are related, but we do not specify what attributes are used for this relationship.

4.2.3 Relational Data Model

Nowadays, the relational model is the most important data model for commercial data processing applications which achieved its primary position because of its simplicity, but in healthcare, sectors are more important because this sector is related to people live, which makes the job of the programmer easy, in contrast to earlier

data models such as the network model or the hierarchical model. In this chapter, you will describe the relational model of Sudanese healthcare model, based on a substantial theory exists for relational databases, Relational Database Management System (RDBMS).

To understand IB in the healthcare context, how to improve the work environment and create a competitive advantage for the organization and how to help in making the right decision based on historical information or integrated data for each to reflect the vision of a more comprehensive. that data it must be transformed to integrated and homogeneous to extract us full information base on this is objective that in most be conceder when create Sudanese healthcare framework that can be classified to internal and external actors base on using BI Tools to interactive with several processes either medical or business and support that extract its Information throe the BI tools technology from verity database it has homogeneous and purification into DW to obtain the desired goals of use benefits of implementation of BI to improve decision in the healthcare sector base on the result of Sudanese BI healthcare framework, when needed intelligence to reach affectivity and quality in service.

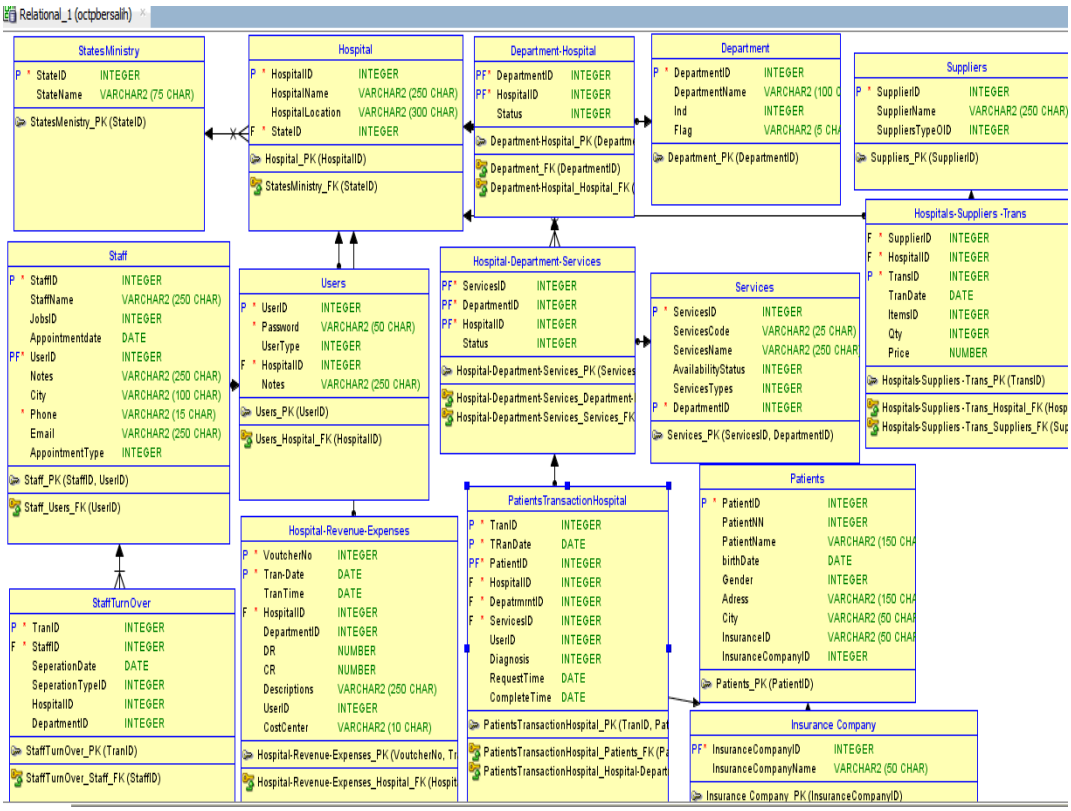


Figure 4-6 Relational Data Model

4.2.4 BI Health Care Framework (Conceptual) Model

As mentions above at the conceptual , logical ,relational models , ant to understanding of BI in health care context, and to implementing BI and its tools in healthcare sectors to improving informed decision in healthcare, we shall determine the operational data either medical or administrative because the data of healthcare is represents the backbone in the process of implementation of BI in this sectors to get the result that must be shown at the information , and restructured this data before migrate it to repository data warehouses (DW), taking into account the external data either the governmental national Information (National Number) or medical insurance information , after that when we needed to information to decision based on the data that has been processed with BI tools and extracting information based on type of decision and according to stakeholders actors either internal or external actors from DW that created by selection important data from any systems of healthcare institutes to be easier to extract information from it base one its needed and privilege of accessibility for any stakeholders , as shown at the Figure 10 :Framework for BI in health care bellow.

The proposed BI framework integrates carefully chosen data from healthcare providers into a central repository to be used by the appropriate stakeholders. The data is selected while maintaining the confidentiality, integration and security of the information.

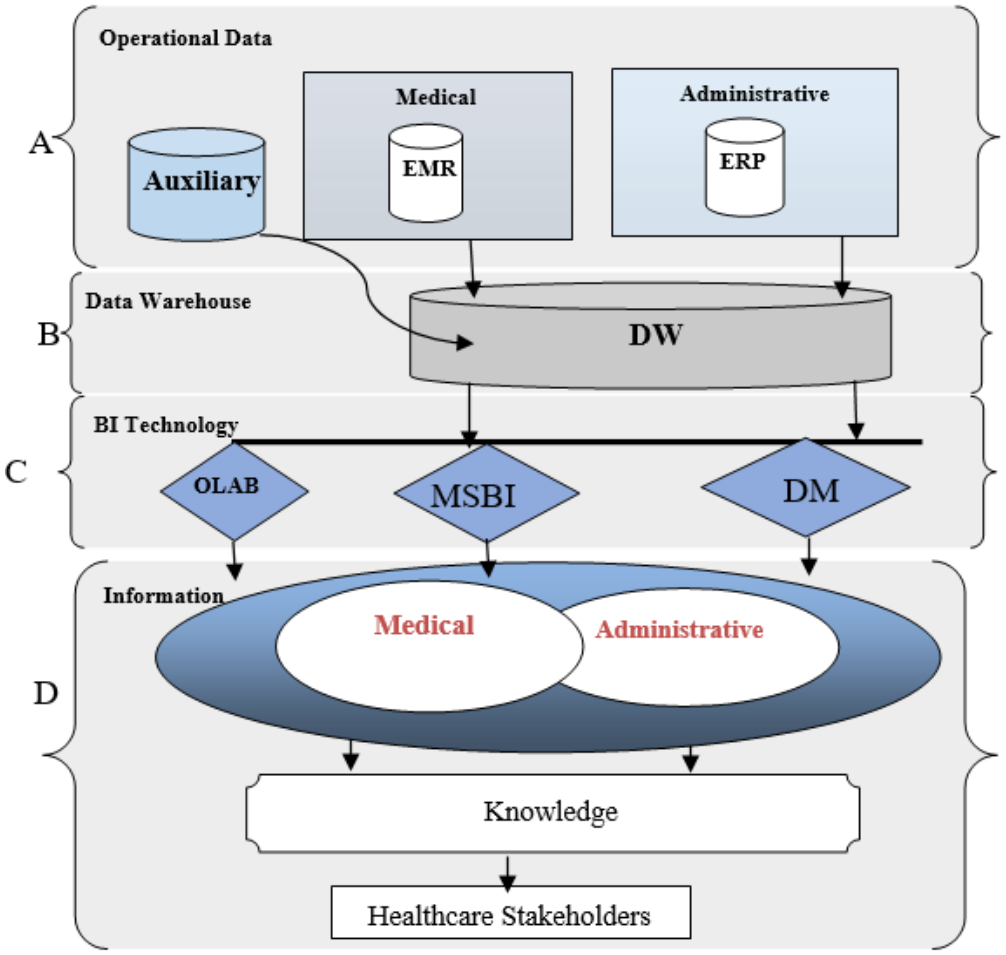


Figure 4-7 BI Framework for Healthcare

The framework is composed of four layers, as shown in Fig. 5-7, and they are described as follows:

A. Operational Data

This layer is composed of transactions data supplied by healthcare providers through their electronic systems as shown in Fig.4-7. This includes unidentifiable patients' medical and services related data as well as providers' administrative data about services availability, cost, human resources, departmental data, etc. The administrative data is included since it has an indirect influence on the operations of the provider. The layer also integrates auxiliary data from the Ministry Of Health (MOH), regulating agencies, international organization such as the World Health Organization (WHO), etc. This layer is the cornerstone of the framework model as

it contains vital data from all participating stakeholders that is essential in building the DW.

B. Data Warehouse

The inbound data from the previous layer is aggregated and stored here in the central repository. Obviously, the BI processes of ETL are performed during the restructuring and migration of the data in the first layer. Access to this digital repository is granted to all participating stakeholders based on their security level and privilege. The objective is to provide them with reliable decision-support information by utilizing BI tools, while maintaining the privacy of patients' personal information and the confidentiality of participating institutes.

C. BI Technologies

This layer contains many BI tools that help stakeholders in understanding the complex processes and data correlations. These include easily customizable visual reporting and querying tools to make timely and informed decisions. For example, OLAP, data mining, Ad-hoc, etc. But in this Thesis to validate the efficiency of framework using Microsoft SQL server BI tools were used for the case study implementation (Microsoft.com, 2020). These tools support BI services concepts by utilizing SQL Server Analysis Services (SSAS) as technology from the Microsoft BI stack to develop (OLAP) solutions, and SQL Server Reporting Services (SSRS) to create reports from multiple data sources with wealthy data visualization either charts or maps.

D. Information

This layer contributes to the creation of the appropriate stakeholders' information dashboards, Key Performance Indicators (KPI), and reports.

In this layer useful information and insight is presented to stakeholder in an easy-to-understand visual manner. Similar to the data layer, the information presented here is grouped based on its type, i.e., medical and administrative.

From the analysis of healthcare processes, and the exploratory interviews, the main stakeholders of the BI framework in Sudan are categorized in the following seven groups:

Government and Regulators*:* This is primarily the MOH and the regional health authorities that manage and control the health sector in Sudan together with

regulating agencies. MOH creates national healthcare policies and procedures, and monitors prevalent diseases and public health epidemics. Regulating bodies have oversight powers over the operation of public and private providers, including hospitals, clinics, labs, etc. They monitor all aspects of the healthcare provider's services.

***Supporting Organizations**:* Such as international organizations like the WHO, and other local and charitable organizations that contribute medicines, equipment, materials and in-kind donations. They provide technical assistance to the MOH and exchange statistical, demographic, and world standards information. They are involved in monitoring epidemics and public health issues.

***Medical Suppliers**:* They supply healthcare providers with medical consumables, pharmaceuticals, therapeutics, medical equipment, etc. MOH and its monitoring bodies regulate these suppliers and exchange specifications, demand data, etc., with them and with the healthcare providers. This data is used by all these stakeholders to plan and make better demand predications.

***Insurance Companies**:* Health insurance companies utilize the medical services availability and cost information of suppliers to negotiate better contracts with them. This is an important factor in reducing the cost of treatment while maintaining quality. They also explore the most common diseases, patients' satisfaction and coordinate with MOH and regulators to improve services.

***Patients**:* They are the central stakeholder that the whole healthcare system revolves around. Patients demand quality service with a reasonable price. The proposed framework helps patients by making the information available.

***Medical Staff**:* These are the physicians, medical and administrative staff at the healthcare providers' facilities. They already use electronic systems that deal with patients' medical records and demographic data. The framework provides them the ability to make better and more accurate diagnosis.

***Healthcare Providers**:* As indicated earlier, most of these providers use electronic systems to manage their operations and facilities. The framework gives them the technologies and tools to integrates their separate data, and to make timely and informed decisions.

This research intends to validate the efficiency of proposed framework provides many benefits to stakeholders. For example, providers and regulators, will be

empowered to evaluate and monitor different performance aspects of the services' delivered against regional and national providers and international standards. While patients and administrators will be enabled to assess services' availability, cost, average waiting times, quality, etc.

To gain greater understanding of the components of proposed BI model and the factors affecting its successful adoption, the next section explores the creation of a basic BI implementation model founded on the abovementioned framework. It also identifies and examines the effect of a comprehensive set of variables on its adoption based on the empirical case study in Sudan.

After describing the components of the BI Framework and how does it works and what the bath of database brings to be information in handle frame or reports and sometimes like the dashboard to make a good decision in healthcare institutes base on the extract information by implementing BI in healthcare sectors, and what the main highlight point of benefits of beneficiaries from the BI framework models. then we need to validate the effectiveness of that Framework in the next sessions.

4.3 Data Analysis

Based on the previous steps findings, and after restructured and reformat the data to be like a collected in the accurate way because when we collected data from different format and heterogeneous and multi-shapes and various types and never standard like Universal Codec or International Classification of Diseases (ICD) and standard service name or code ...etc, because the standardization of labels and the adoption of standards facilitate the process of data integration, which in turn facilitates the analysis of more than one medicinal database, The framework designed to achieve our galls that implementation of BI in healthcare sector using that Framework and validated the efficiency base on similar data in structure and type, at a specific period for three different medical institutions, with three case studies that content more than two factors of anyone and followed with a survey from stakeholders of healthcare. The results of this proposed framework can be compared with implementations resulting from other research in accordance with KPIs, such as improved informed decisions based on three main case studies divided to sub case studies.

4.4 Case Studies

The Sudanese Health System (SHS) uses variance methodology from the perspective of availability of service that must be covered in general for patients and also the health care service cost, all of the institutions that provides healthcare services need to improve the performance of their staff either medical or managerial to reduce medical waiting average time and improve the efficiency of care delivery, and get the patient safety by reducing the medical errors by following accurate procedures, and managing hospital operations, all of this topic reflected on the development of the health sector service, regard to the patients who wish to get a good and full medical service at the same time as one institutes, without needing to immigration from one hospital to another, that become from lack of coverage service. Furthermore, the quality of services and time factor in terms of the service received it's very important as well as the cost it must be within reach for them. all of this point must be taken into account when creating the Sudanese Health Care Framework (SHCFM). to reach the objectives of the research and answer research questions, we have had to put specific situations or case studs as fallow point:

4.4.1 Provider Management

Providing management, it is an important element in the success of any project or institution, so we find in this field of scientific research in which many subjects were discussed, and thy are many papers that talked in this area, but when we take it as a case study in the health sector are getting more important because they are tied to saving the lives of many patients.

Management is one of the influential factors in the reputation and life cycle of the medical establishment, because all the performance and evaluation of the health care organization it reflects on the improving the healthcare sectors, so when we discuss the concept of the provider management in the healthcare sector, it must be viewed from several angles, and aspects can be summarized as follows:

4.4.1.1 Departments

What the departments and disciplines covered by the hospital it has high quality with profitability, and also have higher patient’s frequencies, and thus is it the most

revenue for the institution? Does the institution that depends on the specific departments and is its core business for that institution, that lead to how to say, when we judge the performance of a specific department? and you should keep in consideration how much medical staff in any department, to providers it's medical service to patients, and what are their qualifications? and whether there is a shortage in this department by comparison between revenue and the tarn over of its staff, if it has added new staff will improve the performance of the department, and increase revenue while taking into account the increased expenses.

Is interest in training and qualifying staff will help in the process of improving the service provided and increased revenue and reach to patient satisfaction?

From the above point out that it was necessary to the institution, knowledge of departments in terms of revenue and expenses over several months readings or years which can be evaluated in what is the expansion in what we need to train and reform process, and any departments that are supposed to be present to cover the needs of patients, the for example if an institution specialized department bones must MRI service is available, or departments of medicine in need to all laboratory tests are available to him for the diagnosis, as well as medical endoscopes service simultaneously with medicine and with the help of surgery.

4.4.1.2 Revenue and expenses

The good concept that the institution disbursement on operation generously in order to increase profitability, but it is strategic to turn weaknesses expenses this to the strengths can assist the most in the development of this institution and by analyzing and comparing these expenses for several months or earlier years and establish a policy to avoid and minimize so increase efficiency corporation does not reduce the efficiency.

In this case, we will compare the expenses and Revenue of specific departments in each of the institutions studied and analyzed to respond to the following questions:

What are the highest profitability and lowest operating expenses? What is the relationship between expenses and revenue to the number of employees in the department concerned? Is there a relationship between increased expenses and staff instability?

4.4.1.3 Staff Turnover

Job satisfaction is one of the indicators of the stability in any institution spatially in the healthcare sector, which is reflected positively or negatively on the medical service quality that provided by an Employees with full loyalty to the institution, which in turn reflects on the patient satisfaction from services quality perspective and the way of providing medical service to him. So it is necessary when we refer to the Staff Management within the medical institution that must be seen from several angles, one of these main angles must be what is the frequency of resignations and separation and appointment within the medical institution.

4.4.2 Service Management

Become one of the means of marketing and in particular what is known as e-commerce and e-shops, those institutions or bodies exhibiting their products and it services through electronic media, using different software and different methods and demonstrate the virtues of their products and services as well as specifications and pricing to make it known to those who are looking for, and has become many of the institutions that work in the same area is competing to win the trust and admiration of the audience perfecting their products and reduce their prices and creating a competitive advantage that distinguishes them from other.

Now it became necessary for each medical institution providing medical services to patients who desire for particular service or package of services, and to know their costs and what are the features that characterize each institution for other because it serves the purpose of medical institutions in the following ways:

1. The institution may be understated the effort on service recipients and by clarifying existing and available services, to help patients by providing service or not, and what time is available.
2. Make a competitive advantage through medical service providers, either from the perspective of cost or extent of the care provided.
3. The institution avoids embarrassment the patient's ability to pay during or after receiving the service if he does not have suitable money.
4. The institution avoids the trouble of referring the patient to other institutions if the service were not available and this usually puts it in an awkward position if the patient is in critical condition, it may cause a delay in the referring process lead to

death. On the other hand, the patient targeted for the service available at the institutes, which can serve the statistics research and demand to know why this service is not available and create a competitive advantage between institutes thought the availability of the services.

The medical services, if it's not available can major the desired of this service, which makes the institution management is considering the provision of this service to raise revenue and creating a competitive advantage, to take advantage of the resources available and the development of strategic plans for the progress of the institution, development and increased profitability and reputation. That from an institutional perspective.

Medical coverage from the perspective of patients may vary somewhat because the patient needing the services, because patients want to be all the services in one health institution building, and also to be provided, although it is of high quality and reasonable cost for them. So they should go from the beginning to the health institution providing services requirements they want if their condition allows any comparison between the best institution for them, and they have avoided the lack of service and emigration between health institutions as well as the price may lead the competition among these institutions to provide the reasonable price and available service with high quality and are racing in patient satisfaction.

By using Framework and make the health institutions operates transparently in the field of health care by providing better services and at a reasonable price It will be the first beneficiary is the patient who receives a service in one location without basis referring or multiple completion of treatment or diagnosis sites. Similarly, the institution is obtained at the highest frequency rate of patients, which in turn increases the Revenue is propaganda for a non-paid after obtained their satisfaction from service quality and availability at a reasonable price for them and attention by the healthcare institution.

4.4.3 Time Management

Showing service delays sites and identify weaknesses in service delivery, Is it due to a lack whether the medical staff or manager, or negligence of staff and lack of interest in providing high-quality service in record time to get the patients satisfaction, and reduce their waiting time, which can also contribute to increasing

the rate of services delivery, that in turn increases the institution revenue, moreover it is to adjust the time and reduce the waiting of optimal utilization of resources, both human and devices and equipment if it is looking at them from the angle of the electricity consumption and other used furniture.

Therefore, factor time for health institutions is very important and it can rescue a lot of the lives of patients and achieve higher profitability and the best reputation who produces from patient satisfaction, so it was necessary to be considered one of the case study from two perspectives at the enterprise level as described above or from the patient's perspective on what will be stated.

But from the consideration point of patients is linked to the service is the extent to their care, moreover helps rapid response and rapid diagnosis in rescuing the lives of a lot of injuries and emergency patients, and on the level of critical situations, at the level of the cold cases, we find that the patient does not want to await frequently in receiving services, so that his connections, whether personal or wants to be assured is on his health in record time, or there are co-patient does not want to await frequently because the proportion of the other works he wants to do, so we find most of the patients favors institutions that provide service with quality in less time, that it can become a competitive edge for healthcare institutions are making patients their preferred(comes out from the questionnaire). Therefore, the model can show this feature after validation models.

It is necessary to what extent can benefit from time management whit the result that achieving by implementation BI in the healthcare sector.

So in this case study, we will view the management of time from several angles and from the perspective of patients and from the point of view of the institution, and from the point of view of efficiency and quality of service provided. then we can summaries all Three Case Study in the table below:

Table 4- 5: Case Study Factors and Perspectives

Case study	**Factors**	**Perspectives Describe**
	Departments	Hospitals Department Revenue, Expenses

Providers Management	Staff Turnover	Institutes Turnover. Turnovers per years and jobs. Types of turnover in Institutes
Medical Management	Coverage	Number of Services in Department Insurance coverage
	Cost	Average Service cost in Institutes Units. Selection Service cost in Institutes.
Time Management	Institutes cost	Average awaiting time per minutes .
	Patients satisfaction	
	competitive advantage	

After summaries of the three case study in table 5-5, they are describing the result of analysis for each case study with its perspective and sub-case study as factors for three hospitals.

4.5 Summary

The validation efficiency of framework that creates based on the conceptual, logical, relational models that mention in the chapter (5), based on the structure of the model that content Four layers the first is the basic layer or cornerstone of the model represent all database either clinical or administrative that needs to reprocess, restructuring to store into second layer DW, after many processes to be compatible with the structure of format of the table in the DW that designed at the logical and conceptual models with its relationship.

After extracting all useful information in the DW then using the Third layers, which is how to extract information from the DW based on the type of decision taken, by any of the techniques referred to in this layer that BI tools to help users to understand complex processes and relationships through easily assimilated, customized visual reports that help users to make timely and informed decisions. and the key general categories of (BI) tools are MSBI, Spreadsheets, Ad-hoc, OLAP, Data mining...etc., that us to extract information's of Healthcare Sector Data Warehouses that Content

data from Hospitals or healthcare center .to heap and support decisions using MSSBI tools to enhance decisions based on information.

It should be noted here that the researcher used Microsoft SQL server 2012 BI tools to extract and validate the resulting base on the case study and its perspective taking into account the subcase study and get the resulting base on it, and comparing between then in the chapter (VI) case study result and on the Elementary case study result that represents the type of decision by any case and its sub-cases.

On the Fourth layers actors that beneficiaries form implementations of BI in the health care sectors either internal or external actors, each of them according to its need of information and access to it, depending on their need for information provided by the model, that can be summarized on table 5-5, The overview of beneficiaries multidimensional benefit framework, taking into account the privacy of the data contained in the DW extracted from several databases from several healthcare institutes and suppliers and the insurance company.

The researcher discusses the models' efficiency using three case study firstly the Provider’s Management case study, and it has been discussed from several angles, in terms of the number of administrative and medical departments within the institution and the number of staff and medical staff, and terms of revenues and expenses, and what the turnover of staff or any institutes that effect on the services delivered. Secondly, Services Management because it became necessary for each medical institution providing medical services to patients who desire for particular service or package of services, and to know their costs and what are the features that characterize each institution for other. The latest case study is Time Management since that time factor has become a key factor in the success of the projects, whatever, so time management is a significant feature in many areas.

CHAPTER V

CHAPTER V

RESULTS AND DISCUSSION

5.1. **Overview**

The model was implemented to explore the benefits achieved by stakeholders from adopting BI technologies. Information dashboards were created reflecting the target group's (providers X, Y, and Z) administrators' and patients' perspectives. Results belonging to each of the three influencing factors groups outlined in the previous section are discussed in detail, and their impact on the study objective is highlighted.

Results are based on the BI implementation of the information dashboards created for this purpose. The target group administrators' goal is to optimize resources and assess their services' and pricing competitiveness. The factors examined in the case study are medical services' availability, patients' frequency, staff turnover, revenue, expenses, among others. The cornerstone of validation the efficiency of the framework based on the obtain of the results to explain information of each case study clearly to the stakeholders, this is what was done in the previous paragraphs where the case study was divided into three axes. Firstly, provider's management, which it has been discussed three aspects, either from the concept of healthcare institute departments with its staff within its services that deliver, according to expenses that mention to what is the relationship of expenditure to revenue for each department, or its relation to job satisfaction in the section concerned with the higher and lower-revenue segments and also the relationship between job satisfaction and turnover of employees, to meet the research objective as and also answer the research question for enhancing the healthcare sector from providers perspective, and improving decision making.

Second of case study Service management divided to concept of medical service availability and service cost. The service availability discusses the nature of the services available in the health institution concerned and was viewed from several perspectives, whether in terms of patients or the institution concerned and its competitive advantage, to meet the research objective as and also answer the

research question for enhancing the healthcare sector from providers, and patient's perspective, and improving decision making.

The last case study is related to Time Management since the time factor has become a key factor in the success of the projects, whatever, so time management is a significant feature in many areas. But when we talk about time in the healthcare sector, it means that we weigh things fewer units of measurement of what is important, whether, from the perspective of patients or their companions, one minute may save life. On the other hand, the healthcare institutions itself, considering it an increase in expenses and reduce the competitive advantage, to meet the research objective as and also answer the research question from many perspectives.

5.2. **Providers Managements**

In light of the concept of the case study that determined in the previous section, with its subcase for each main case study, shall analysis it for three healthcare institutes (X, Y, Z) subject of study, and in this analysis section must be viewed in below graphics, how the implementation of BI in Sudanese healthcare through the proposal framework, to enhanced this sectors by improving decision-making form administrative aspects focus on managerial and financial factors, and also the efficiency of department such as staff managements factors, to achieve the improving services quality, integrating departmental information, to improving informed decisions in the healthcare sector based on BI and DSS implementation.

As mention above the validation to validate the efficiency of framework through providers management we shall applied on one institutes (X), because the managements reflect the administrative decision-making, that means it must be from hospitals perspective, the validation analysis on hospitals (X), but it can be applied on the other hospitals data, the select of hospitals (X) not for limitation but to approve the efficiency of the framework proposed within sample of this case study, but when we analyze case study medical coverage we shall compare between three hospitals(X, Y, Z) also included all department for each hospital services that covered by its department, and compare between each hospitals how many services in that department and what department covered for services and also what is the

cost of services and compare it between location that is important from a patient perspective more than institutes perspective.

The validation using provider's management's perspective it divided to four factors:

5.2.1. Hospitals Revenue and Expenses

Revenues and expenditures are the main concern of many profitable institutions, and in the health sector as well, so we find that the proposed model can summarize this information and present it to decision-makers in the form of its graphs to help in making the decision, by determine the department it has a high revenue, besides other departments, it is the lowest revenue that maybe need to re-evaluate this department, is these departments it has bad guilty of services? or there is short in staff? or needs more turning? or needs more marketing to this department?, All of this quotation a beer by using BI tools, to decide by general managers or shareholders of institutes, and taking into account the turnover of staff in that department to analyze job satisfaction to employees, and also patient satisfaction in that department. But the revenue it is not enough to say that department is the highest revenue. We need another angle of view, the analysis should be compared to the revenue against expenses through discussion with an integrated view from several angles, to take accurate decision by using the result of this module that seen in sub case study department revenue for any institutes and compare it with sub case study department expensive.

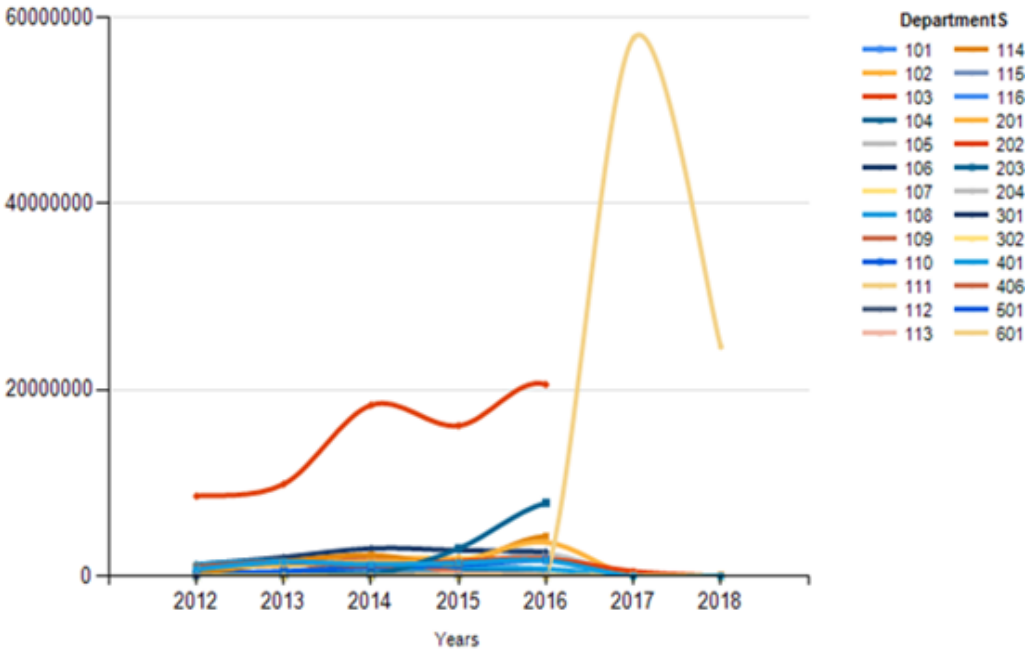


Figure 5-1 Hospital Department Revenue (X)

Figure 5-1 reflect department revenue in the institutes (X), that can help managers to make accurate decision based on revenue information through the Framework, and justify the gaps between departments revenue, and how to let them in same rang of revenue to improved them from increasing revenue perspective, which focus on the high-revenue, as well as supporting the expansion, while increasing the low levels of qualification of its employees and re-establishing its marketing policy to attract patients, taking into account the less performance, which means less revenue and less frequency, that serve directly the institutes and its managers or shareholder when shown the indicators to contribute with development, to avoid the hospital the financial risk and get profit, that also contributes to the management of medical institutions to the continuity of services of patients, and also helps patients to identify their destinations in the case of needing a request service for a specific department.

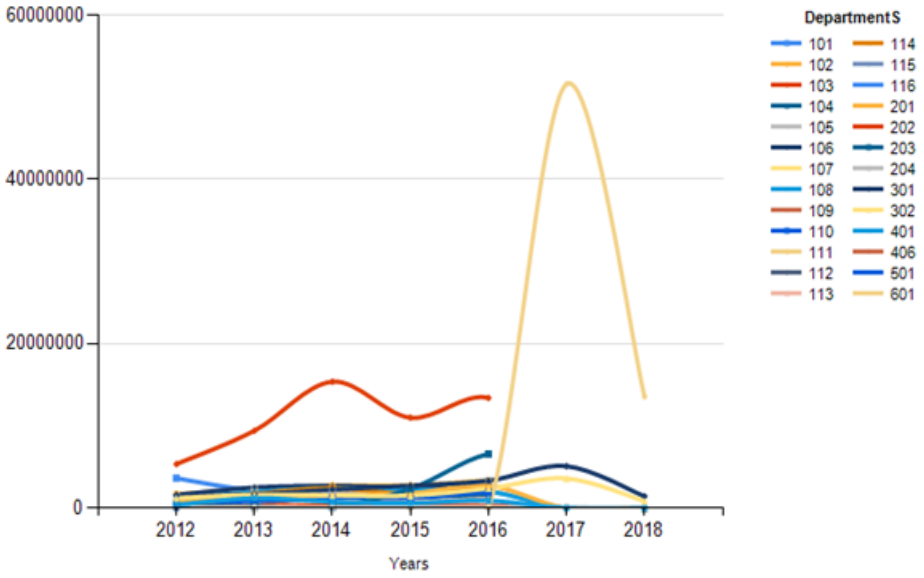


Figure 5-2 Hospital Department Expenses (X)

The results in Figure 5-2, indicated to expenses for hospital(X) show there are departments that fluctuate expenses and there is stability in some of them, noting a jump in expenditures in the last year, and this is what helps in applying business intelligence because there is a justification for the administration, or looking at it as a threat. As expenses are sometimes considered to be how higher revenue is obtained, some departments are promoted to attract patients and increase their frequency, sometimes there is a loss of a specific department, but this loss may bring profits in other departments.

So the process of analysis here that represented by the models is important to explain the reason for the variant between the departments to the institution's managers and stakeholders so that they can develop a long and short term policy for the institution based on the information obtained through the implementation of BI in ours hospitals based on historical data gathered to form a large period, what is the justification of the institution not to raise the level of service in those departments to reach a point of balance and then start to the level of profitability.to fill the loss gap and ambition to increase revenue and reduce the expenses, all of that help to decision making base on the results of BI implementation in healthcare sectors.

5.2.2. Hospital Efficiency

The efficiency of any hospitals is measured by several criteria, often are overlapping and cannot be separated from each other, especially in institutions have service nature, let alone the health sector, so the efficiency in health institutions affected by many factors, either such as management and delivery of good service, patient satisfaction, and other factors, but they are all centered on the access of patients to distinguished service and affordable price, this is reflected in the general frequency of patients for a particular institution, and sometimes there is a specific department within the institution is the best efficiency, when we looked at the measures of efficiency, we found that it is better to measure the frequency of patients in the medical departments related to clinics specialized in each institution, and from the results that will be shown to us by the data by identifying the highest clinics is the frequency of patients for each institution to show us how many patients were accustomed to that specialization in the period covered by the processed data, so we have identified the clinics intended by patients in each institution and the standardization of the names of clinics that are common between them, noting that there are some units that characterize the institution of the other that show at Table 5-1.

Table 5- 1: Institutes Patient Frequency

Numbers	Outpatient Clinic	Patient frequency by institutes		
		X	Y	Z
1	Kidney	3	6	381
2	Anesthesia	6	56	No available
3	Physiotherapy	62	No available	No available
4	Other	167	34	No available
5	Plastic	168	3326	No available
6	Psychological	309	No available	16
7	Radiologist	364	37	15
8	DOCTOR	387	2399	1099
9	Oncology	No available	No available	1238
10	Throat	514	105	3330
11	Dermatology	600	1302	37
12	Ophthalmologist	620	No available	No available
13	Urologist	978	36033	1750
14	Obstetrics	1360	11137	3753
15	Surgery	2392	52850	2139
16	Cardiology	3406	92	1029
17	Endoscopy	3835	31	700
18	Orthopedic	5752	31435	5570

19	Neurologist	8931	248	917
20	Pediatrics	12392	1964	4528
21	Medicine	17154	8592	8748
Total		59399	149647	26502

Table 5-1 is one of the results of BI framework represent availability and services covered on the three institutes and reflect the institutes' efficiency by represents many factors of majoring either from institutes or patients at the top of the availability of service or covered of service and also unique competitive values, the summarize of result that represents as the table above base on the result of BI tools, viewed any institutes it has competitive advance excellence from another institute, for example, institutes (X) it has to clinical units characterized by it alone, and also institutes(Z) characterized by Oncology clinics only, There is also a distinction between two non-third institutions for example institutes (X, Y) shared characterized in Plastic Clinics, and institutes (X, Z) shared in Psychological clinics. The next institutes' efficiency sub case study indicators related to this hospital specialization patient frequency efficiency so the efficiency of consultant in these units that represent above.

The factors of hospitals efficiency are one of result of framework reflect its effective of the framework, to explain the efficiency of hospital department unit’s e as dashboard to enhance decision making for improving this sectors.

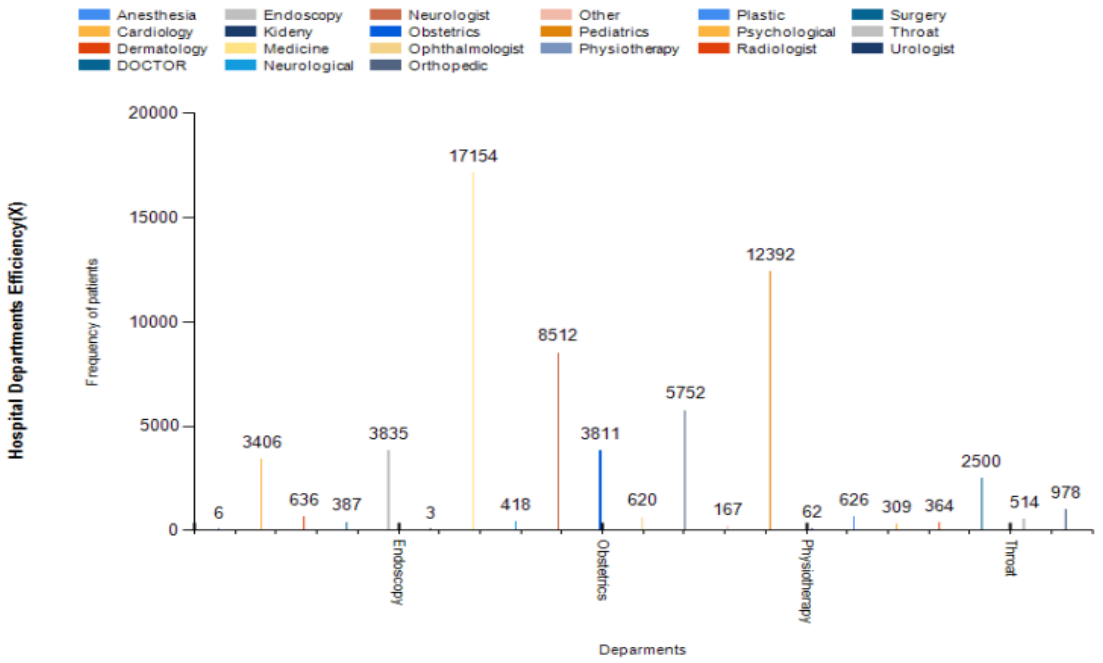


Figure 5-3 Hospital Efficiency (X)

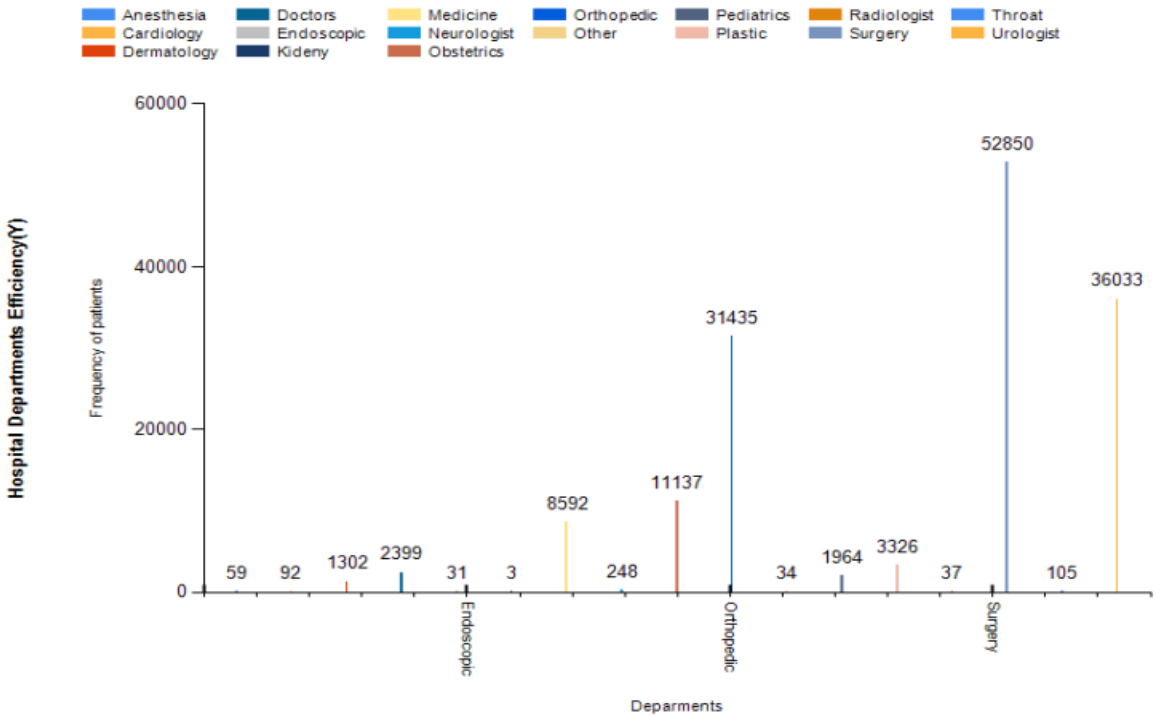


Figure 5-4 Hospital Efficiency (Y)

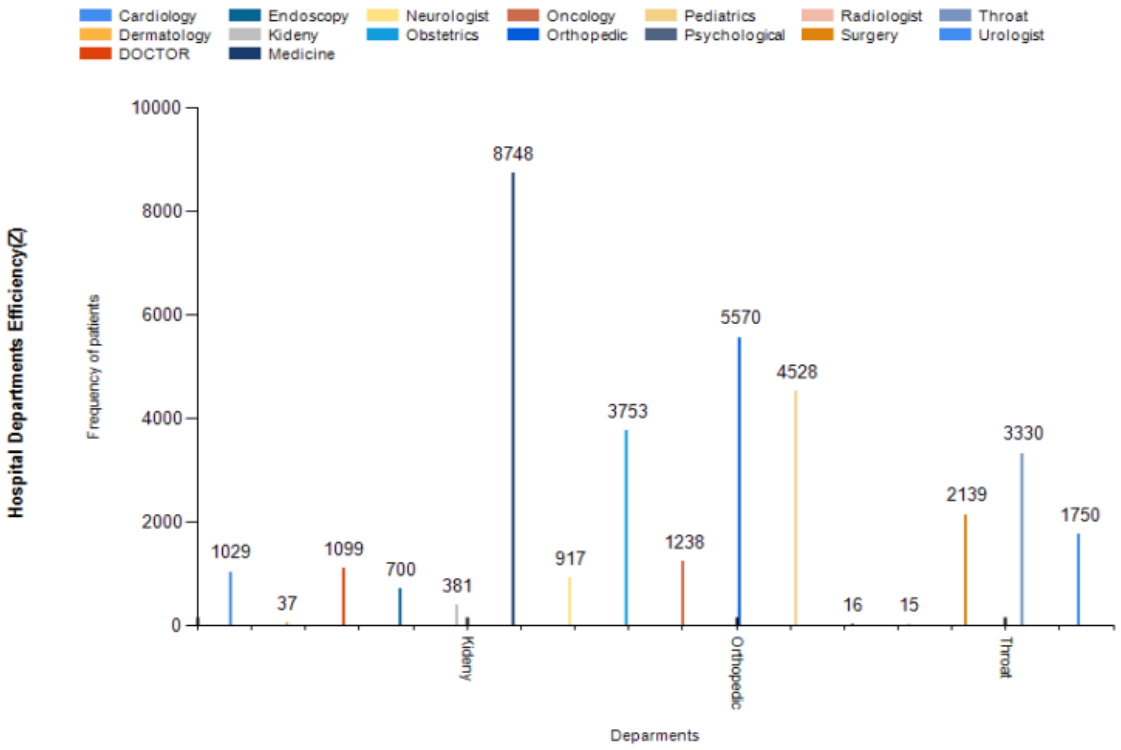


Figure 5-5 Hospital Efficiency (Z)

Figure 5-3, 5-4, 5-5 represents the hospitals departments patient frequency to reflect the efficiency in the three hospitals, that represents in above graphics, reflect the information for any physician clinic, to decide what is department it is heights frequency of patients, that means it is good department for the hospital and so for patients and good reputation. Also the framework creates deep information of efficiency of hospital by getting this factors representing dashboard of hospitals patient frequency for any physician at any hospitals departments.

The effectiveness of all disciplines in the three medical institutions was reviewed in the previous case study, thought the framework model generates information to related stakeholder to make accurate decision based on a variation between different departments from one institution to another, which reflected that there are specialize have a highest frequency of patients and this means that it is the most effective in that institutions, and then it has achieved the patient's satisfaction so was the frequency of the highest.

The results, as indicated in below graphics, show that in deeply details of departments have higher efficiency through BI tools in Framework model, to

determine how many consultants work in the higher specialization, who is the highest consultant on the efficiency of peers, and how many patients visited during this period in which the data was processed, taking into account the fabrication of the amount of data between institutions.

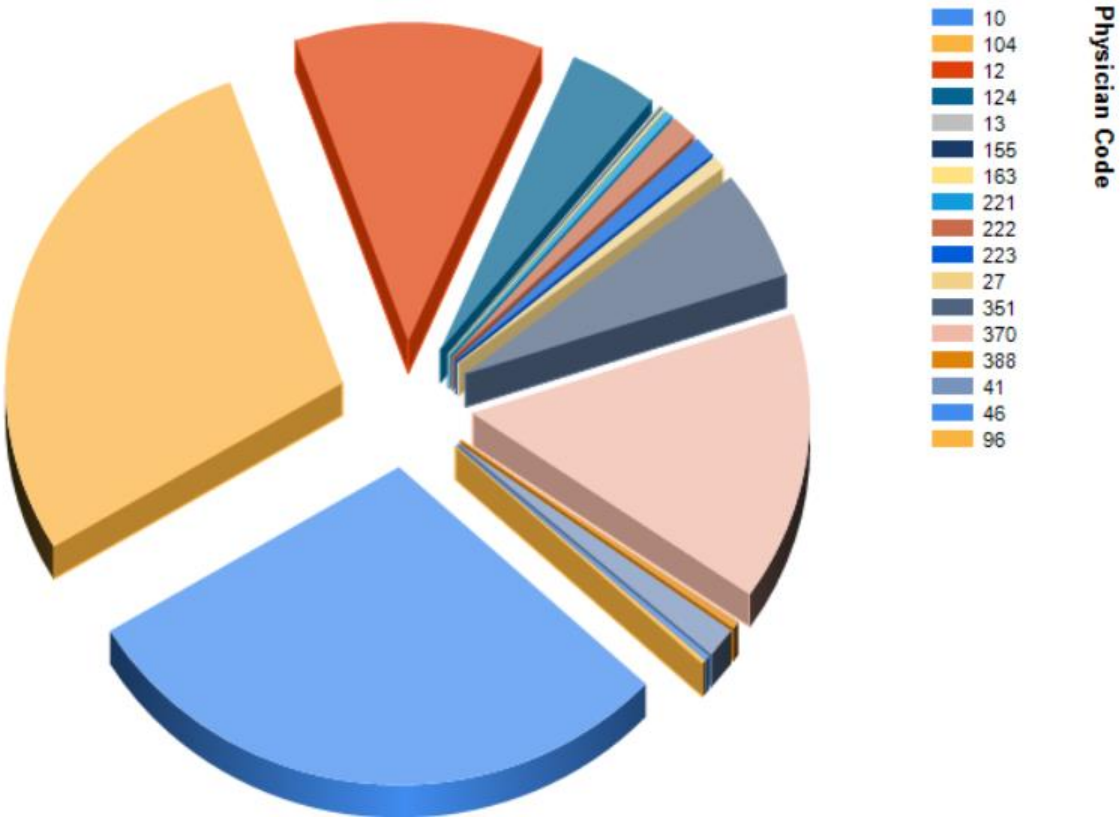


Figure 5-6 Physicians Efficiency in Medicine Institute (X)

Figure 5- 6 represent the result of physicians efficiency in the institute (X) above describe the number of the consultant in the medicine specialize that it has most efficient and difference patient interview the consultant in medicine department at institute (X) for the example of how to the implementation of BI can help the healthcare stakeholder through the available information dashboard, to determine with no more than patient visits have four patients during this period, all this information it became available to authorize stakeholders to evaluate and make the decision, and so important for the patients.

5.2.3. Staff Turnover

Job satisfaction is one of the indicators of the stability for any institution spatially in the healthcare sector, and one of the indicators factors of provider's management

case study, which is reflected positively or negatively on the medical service quality provided by an employee with full loyalty to the institution, which in term reflects on the patient satisfaction from the perspective of services quality. So it is necessary when we refer to the staff management within the medical institution must be seen from several angles, one of these main angles must be represented by BI tools, what is the frequency of resignations and separation and appointment within the medical institution, and how many turnovers of staff in the institute and what is the jobs it's a high turnover that it must be given indicator to the managers either the salary it's satisfied or the environment it needs to be reevaluated, and what is highest department turnover, and the institute it must justify it and clarify. Because the employee's career stability has an impact on the performance of the institution and its profitability and also affects the revenue and expenses, and the continuous training process, which in turn affects the satisfaction and safety of patients, and also the loyalty of the employee to the institution is an indicator of the success of the institution.

In this sub-case we will try to reflect of implementation of BI in healthcare sectors with its tools after reformatted and restricted information, to represent the results of what is turnover for the type of jobs for any institutes per years or turnover types for each institute and number of any turnover for all beside summarize each subcase study indictors in a table summary.

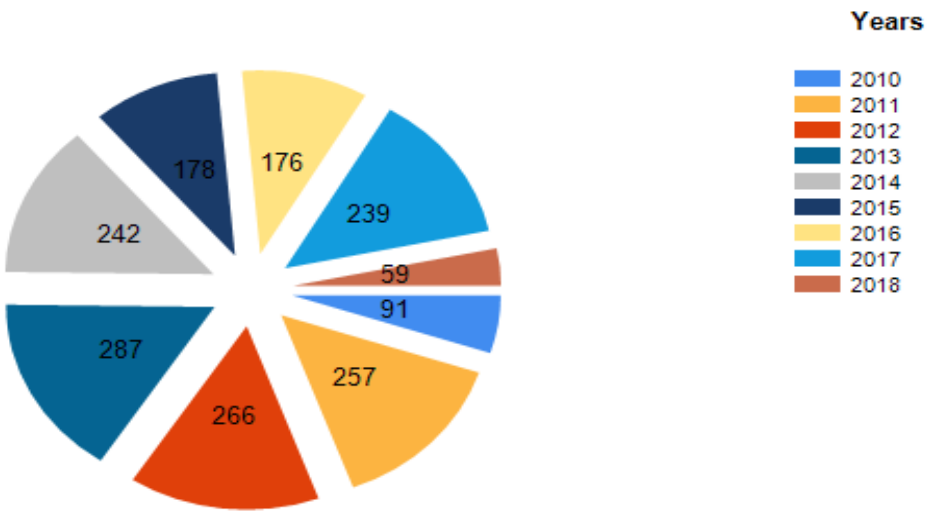


Figure 5-7 Staff Turnover Hospital (X)

To enhance decision-making to improve the healthcare sectors from human resources perspective, Figure 5-8 represent how the framework providing the stakeholder with employee's turnover per years to determine the reason of that, because the job satisfactions this is supposed to reflect positively on revenue and patient satisfaction, as shown in the Figure 6-8, for example result at the hospital (X), but we can apply that for any hospital using this framework. And represent the relationship between the staff turnover with their job type to see what is the highest turnover job type? and what is the highest year for each job type? all these questions we shall represent the result as bellow graphics for the hospital (X) also.

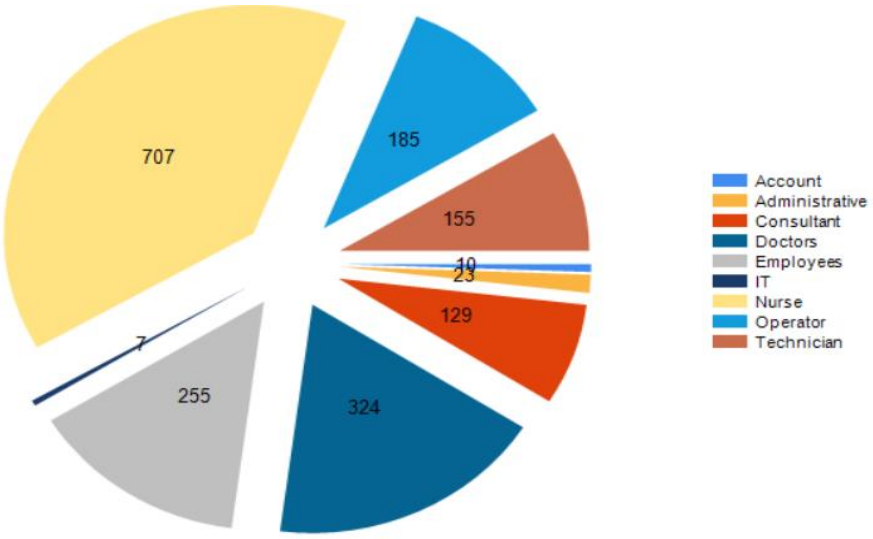


Figure 5-8 Staff Turnover Per Job Type Hospital (X)

The Framework model also provides decision-makers with regard to employee's turnover, in-depth information about turnover for each job type in Figure 6-8, as shown above through graphics result, and we can summarize them in the below table:

Table 5- 2: Staff Turnover Per Years and Job Type Hospital (X)

Job Types	Years									Totals
	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Account	1		4	-	2	1	-	1	1	10
Administrative	4	5	2	4	2	1	2	2	1	23

Consultant	11	46	32	16	14	5	2	3	-	129
Doctors	9	30	28	49	40	48	45	60	15	324
Employees	10	26	37	47	30	25	25	44	11	255
IT	-	1	-	2	1	1	-	-	2	7
Nurse	32	84	120	101	94	67	80	110	19	707
Operator	8	18	26	47	41	18	10	13	4	185
Technician	16	47	17	21	18	12	12	6	6	155
Total	91	257	266	287	242	178	176	239	59	1795

Table 5-2 represent results of BI framework summery of employee's turnover per years and job type at institutes (X), that reflect information of turnover in that institutes' based on the jobs type to distinguish between them to determine what is highest turnover through framework model, the turnover on the period of data that gathering from years 2010and till March 2018, and this result base on BI tools after reformatted and restriction information, to reflect that jobs of nurses are the highest turnover, with a rate of 32for 2010and 84for 2011and 120 for 2012 and 101 for 2013 and 94 for 2014 and 67 for 2015 and 80 for 2017 and 19in the third month of 2018, followed directly by doctors jobs type and employees consecutively, also it summarizes them in the below table.

After represent above how the implementation of BI in healthcare institutes supports the stakeholders or managers to summarize the information of turnover using a dashboard or information table to be able to make the decision based on timely information.

The staff management factors its sub case study, and showing the results presented by the framework model, and also show how useful it is in extracting the information to be useful to the patients and the institution to make the decision when meeting its objectives, it will be discussed and their relationship with another case study to give the best details to make the appropriate decision, so in the next paragraph we will review the case study of medical services coverage.

5.3. Service Management

The services coverage by medical institutions is attracting patients who come to get services, but sometimes patients are forced to move between more than one institution, either because the service is not available at the first services provider, instead because the price in that institution is not affordable hands.

So during this case, we show what services are covered in each healthcare institution under study (X, Y, Z), and what is the price of each service or average price in any institutions, Taking particular sections to present the result of service coverage, and the cost of services, and then taking them together to present the competitive advantage of each institution, from the perspective of cost and coverage so that the patient can identify his destination from his home, and here, in this case, study determine three departments (Lab Department, Outpatient Clinic, Radiology) per institutes, because it may be shared in most health institutions with different internal details in terms of coverage of services and prices.

5.3.1. Service Availability

The process of medical services covering in one institution is a basic factor in the patient's point of view so as not to be surprised that he needs a medical service that is not available in this institution so he has to move to get it from another institution and bring its result or report to the physician in the first institution to complete diagnosis for treatment. Or after his arrival to the organization, surprised that there is no service required by the specialized specialist in the designated specialization so he wasted his time in reaching the wrong institution.

Therefore, the researcher should test the model in terms of saving time for the patients so that the services coverage by the model that we are testing and applying will be determined in two sub-case studies, either the number of service coverage in the department of insurance coverage in any institutes.

5.3.2. Department Services

In this sub-case, we will show how many departments available in each of the three institutions under research, and how many services available for each department in hospitals, without going into the details of the services that appeared to us as a result of coverage when we verify the cost of services. The result below represents the

service coverage in the Outpatient Clinic, that means how many consultants in the institute in different specialization or department?

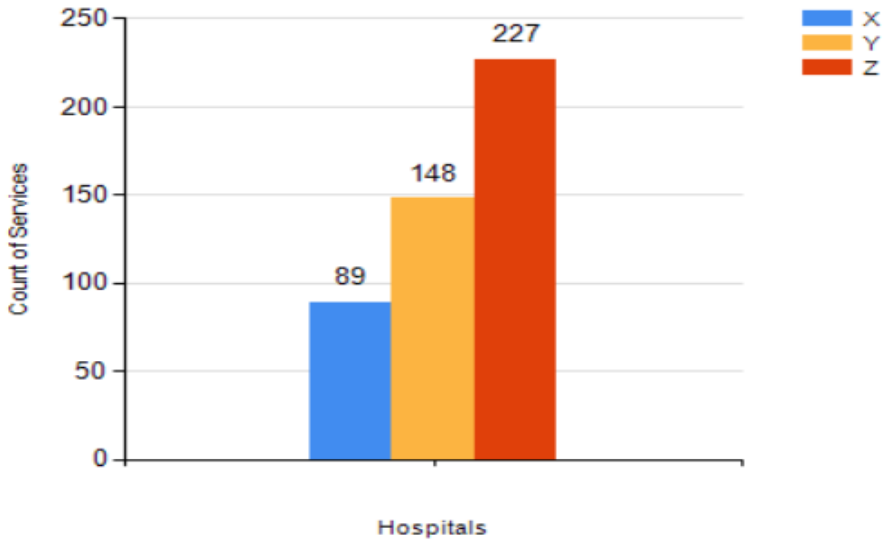


Figure 5-9 Outpatient Clinics on Hospitals

Figure 5-9 represents the result, that captures the number of specialists who can be interviewed by patients in different specialties, which differs from one institution to another. The greater the number of specialists, the greater the specialization department, as the number of specialists is directly proportional to the specialties in healthcare institutions, and the patients receive their services in less time, Therefore, we observe that institution (X) is better from the patient's perspective, with several specialists 227, followed directly by an institution (X) with 148 specialists, and then delayed in the back (Y) the number of 89 specialists.

After representing through BI Framework in Sudanese healthcare sectors the number of services is covered for each hospital, also the framework can represent to healthcare stakeholders the clinic units or clinic spatialize is availability and coverage for outpatients clinic for delivering the services to the patients, or hospital specializations department for each institute under study (X and Y and Z) that represent it results when discussing the frequency and efficiency of subcase study hospital efficiency, but he in this case study represents from a service coverage perspective, that means what the Outpatient Clinic coverage.

Table 5- 3: Clinics Coverage for Hospitals

Numbers	Outpatient Clinic Units	Units coverage		
		X	Y	Z
1	Kidney	available	available	available
2	Anesthesia	available	available	No available
3	Physiotherapy	available	No available	No available
4	Other	available	available	No available
5	Plastic	available	available	No available
6	Psychological	available	No available	available
7	Radiologist	available	available	available
8	DOCTOR	available	available	available
9	Oncology	No available	No available	available
10	Throat	available	available	available
11	Dermatology	available	available	available
12	Ophthalmologist	available	No available	No available
13	Urologist	available	available	available
14	Obstetrics	available	available	available
15	Surgery	available	available	available
16	Cardiology	available	available	available
17	Endoscopy	available	available	available
18	Orthopedic	available	available	available
19	Neurologist	available	available	available
20	Pediatrics	available	available	available
21	Medicine	available	available	available
Total		20	17	16

Table 5-3 is representing summarization of information of clinic units or clinic spatialize is availability and coverage for outpatient's clinic for delivering the services to the patients, based on the Framework using BI tools, and capture how are hospitals have a competitive advance from another institute, by it has more clinical units characterized, and delivered more services than other hospitals, that information it is more suitable for the patients to aimed to it when needs to gets services.

After representing information availability of clinic units or clinic spatialize is coverage on the three hospitals, also framework represent this information in details for each unit, for example, how many services is covered in those units here in this example is selected to units (Lab and Radiology) to represents the service coverage in them, that means how many service coverages in the institutes by Lab department or Radiology department respectively.

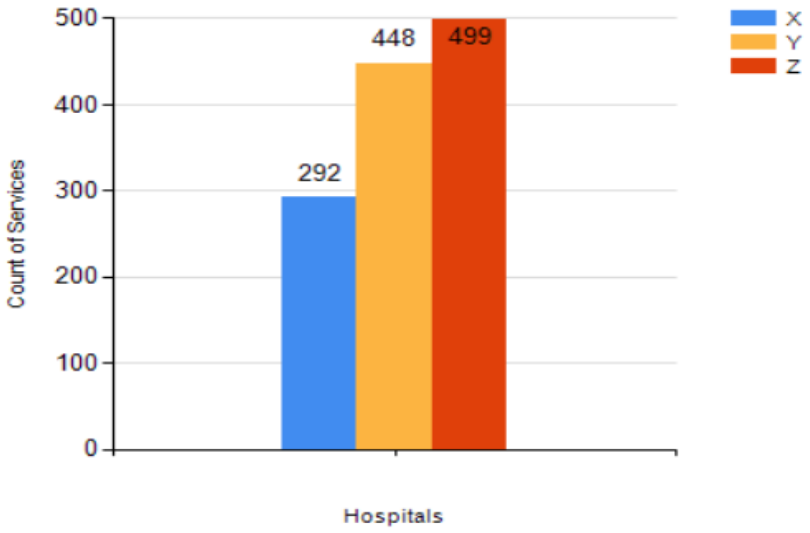


Figure 5-10 Services Coverage in Hospitals Radiology Departments

Figure 5-10 represents the number of services is coverage by the three institutes at the radiology department, which differs from one institution to another. Therefore, we find that institution (X) is better from the patient's perspective because it provides the most diagnostic services, with many service 499 services, followed directly by an institution (Z) with 448 services, and then delayed in the back (Y) the number of 292 services.

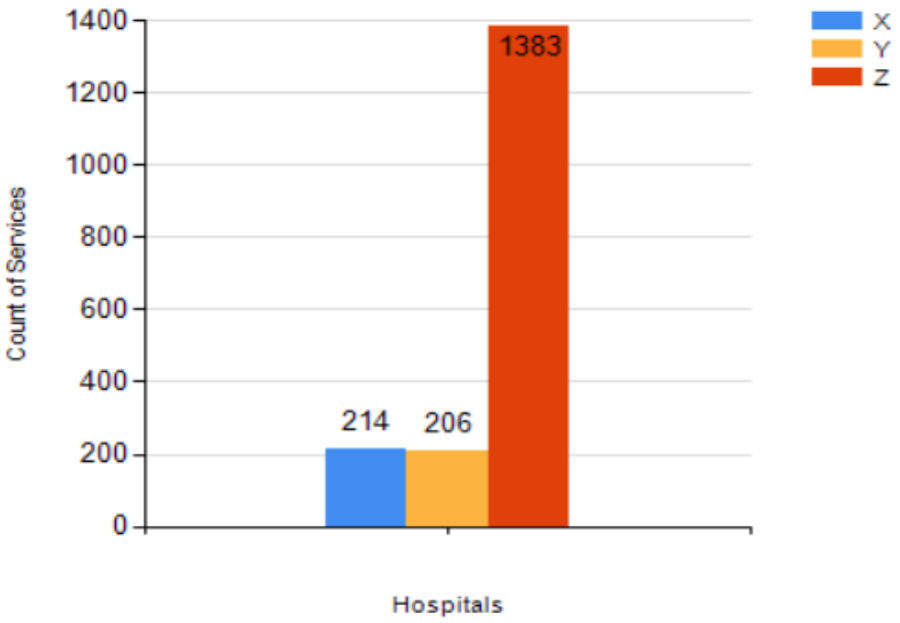


Figure 5-11 Services Coverage in Hospitals Laboratory Departments

Figure 5-11 represents the number of services is coverage by the three institutes in the lab department, which differs from one institution to another. Therefore, we find that institution (X) is better from the patient's perspective because it provides the most laboratory tests services, with several service 1383 services, followed directly by an institution (Y) with 214 services, and then delayed in the back (Z) the number of 206 services.

After representing the result of service coverage for each separate department selected (Lab Department, Outpatient Clinic, Radiology), then we can summarize all three departments service coverage at the bellow table:

Table 5- 4: Service Coverage for three Department

Department	Institutes		
	X	Y	Z
Outpatient Clinic	227	89	148
Radiology	499	292	448
Lab	1383	214	206

Table 5-4 is representing summarization of information of three selection units or spatialize which has services coverage for patients to deliver the services to the patients, based on the Framework using BI tools, and capture how are hospitals have a competitive advance from another institute, by it has more units, and delivered more services than other hospitals, that information it is more suitable for the patients to aimed to it when needs to gets services.

5.3.3. Service cost

The advantage of the model is that the patients can see the comparison of prices, that estimation of the prices to determine the patient's destination for service concerning to the quality of service, which is also determined by several factors, including patient satisfaction and time factor here in his result we can see how the difference between three sites for any service cost.

But from the institute's perspective, the service cost is a double-edged sword, for example when the cost of services is affordable to patients, then they have height frequencies, which in turn increases the revenue of the institution and makes the institution the same competitive advantage for its peers, but also reduces revenue compared to expenses if there is no balance.

a. Average Service cost in institutes units

This subcase study presents the average service cost for each institute, on any healthcare services provided by a specific department or unit, because maybe there is a variety on the number of coverage of services, from one institution to another and reflect negatively or positively on the average price of service in a particular unit, that information it will use for the healthcare stakeholders to make a decision using the implementation of BI. on this paragraph represent what is achieved from using the implementation of BI either from patients or institutes perspective.

The result of average service cost in institutes units for each institute individual represent how to achieve implementation of BI in healthcare sectors to create comparative between institutes to recast of service to become on fordable to patients, that from patients perspective when fetching for a fordable service, but from the perspective of institutes it achieving represent its services that coverage to increase the turnout of patients because its services it is on patient hand beside the number of services coverage that represents.

That leads institutes to conduct planning base on its budgeting, and forecasting more efficiently when merging the subcase study hospitals' efficiency by its cost get increase outcome and reduce cost, attract the patient, this is consistent with the research objectives.

b. Selection Service cost in institutes

This subcase study validates the model efficiency by using select common five services from two units (Radiology, Laboratory), to estimate service cost between three institutes to verify if there a difference between then the result explored bellow, the selection randomly for common services on tow unites, to determine service cost of service is it vary from one institution to another? Although it is a single service, hence the trade-off is that the model has been successful for the patient who is looking for price comparing, or the cheap price service. that patients, in this case, we can go to get its service from on hand for him besides other factors that provided

by the model and creates a competitive advantage competing with medical institutions, which leads to quality of services and reduce the cost of treatment.

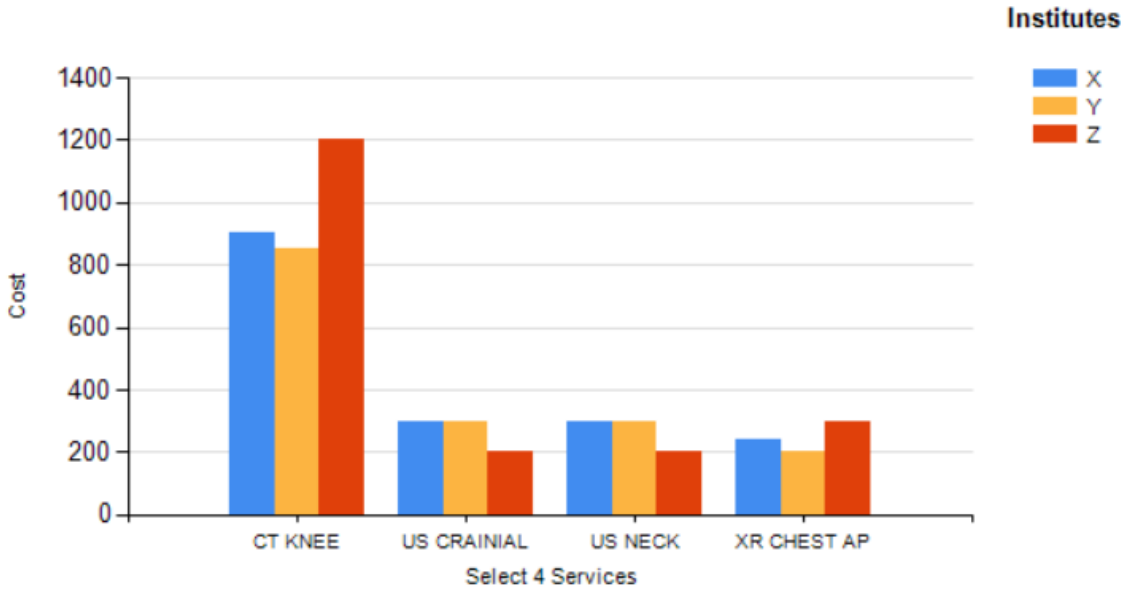


Figure 5-12 Comparison between Selected Hospitals Radiology Service Cost

Figure 5-12 represents through BI framework model of information dashboard that contains the cost of four services in the Radiology department, that common and sharing services and there are available in three hospitals, make the capture represents the cost as information price to healthcare stakeholders to making comparison process from an affordability perspective, we review the results that were reflected by using the BI tools in healthcare sectors especially in the Radiology unit that represent its result above. by using the following four services (CT KNEE, US CRANIAL, US NECK, XR CHEST AP) were selected, we notice that there are sometimes differences in services prices selected, this feature makes by using a model after implementing BI tools, to serving both the institutes and patient parties.

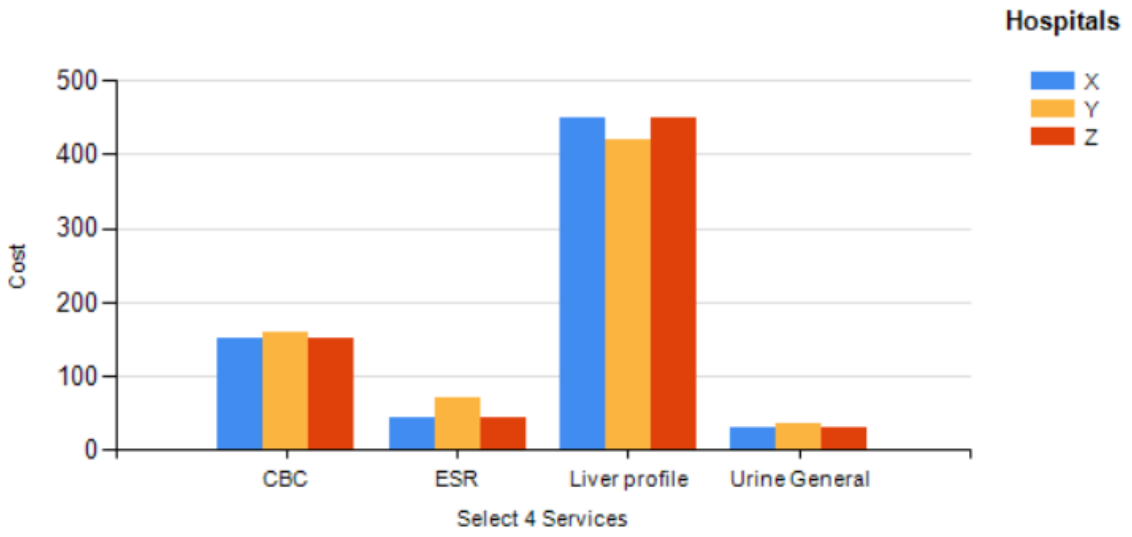


Figure 5-13 Comparison between Selected Hospitals Lab Service Cost

Figure 5-13 represents through BI framework model of information dashboard that contains the cost of four services in the Laboratory department, that common and sharing services and there are available in three hospitals, make the capture represents the cost as information price to healthcare stakeholders to making comparison process from an affordability perspective, we review the results that were reflected by using the BI tools in healthcare sectors especially in the Laboratory unit that represent its result above. by using the following four services (CBC, ESR, Liver profile, Urine General) were selected. As the result in the above graph is shown and summarized in the following table, we notice that there are sometimes differences in services prices selected, this feature makes by using a model after implementing BI tools, to serving both the institutes and patient parties.

But using the results of the trade-off price may equally between the two institutions like the result as in the example below. So the decision is based on more than one factor, either the price and the time of the process of coverage are naturally present only to include the price range.

We can be summarized case study medical coverage and it's the subcase study, that making the patient have more than one option can be seen from several angles to achieve its services, for example, cost or cost with coverage or both together with the services quality. Etc., or from the point of view of the institutions all of these criteria that the patient considers the service he wishes to receive, the model has

created a competitive advantage that enterprises can compete in their market place after implementation the BI and its tools.

5.4. **Time Management**

The time factor is often the most important factor in measuring the effectiveness of institutions that delivered any services, as well as the quality of services. The faster the service is offered, the more competitive it is, as time is an important factor in most areas. In the medical field as the first work, the speed of response and reduce time in any health institution leaves a positive impression on patients, in the emergency, for example, may save the life of a patient.

In this case, the study represents how to use BI tools in healthcare sectors, to achieving minimize patient waiting time when deliver is services, to be satisfied from institutes policy, that reflect the efficiency of care, then we can be divided meager of time form several perspectives:

The waiting of time, the time spent by the patient until the beginning of the service either treatment service or interview with the physicians. We can calculate the difference time between arrival time and delay in the queue.

a) The time spent while receiving treatment we can call it service time.
b) The time that a patient is waiting to get other services that is complementary to diagnosis.
c) The patient's waiting time is received for the complementary diagnostic service.
d) The patient departure time with satisfaction or not after complete its treatment.

In this case study we can validate the efficiency of Sudanese healthcare framework models by getting a result and achieve the effectiveness of models by using three measure for any institutes:

a) Average patients service time (service rate)?
b) Average patients delay (Average patients wait)?

The available calculated from data that gathering from the institutes under the study, and they're not under control the time of arriving of patients and time of departure

patients, so in this case study we will just review the Average patient's service time and Average patients wait, for each institute and review it from tow perspective either from institutes or patients.

The result bellow was taken from the data after restructured and formatting for July 2017, because it gives the required indicator for all institutions.

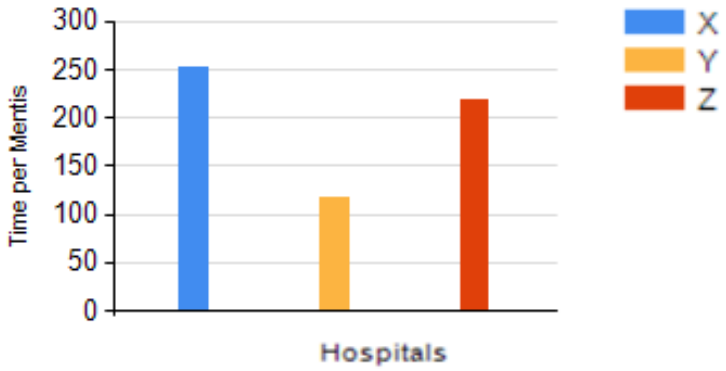


Figure 5-14 Hospitals Service Average Time

Figure 5-14 represents the information of the average time of services per minute that patients spend while receiving the treatment service, for example, the time spent with the doctor or during the operating room and during the radiography, etc. This time may precede a process of waiting according to the specified time and may vary from patient to patient and doctor to doctor.

There is a large operation that takes more than 12 hours, for example, all of which should be taken into account through the model we are representing the results of it, to be achieving its benefits from both the institution and patients. The results represent hospital (X) is the highest average service time with 250 minutes and immediately followed by institutes (Z) with 217 minutes and the low average service time is institute (Y) with average time 117 minutes per services.

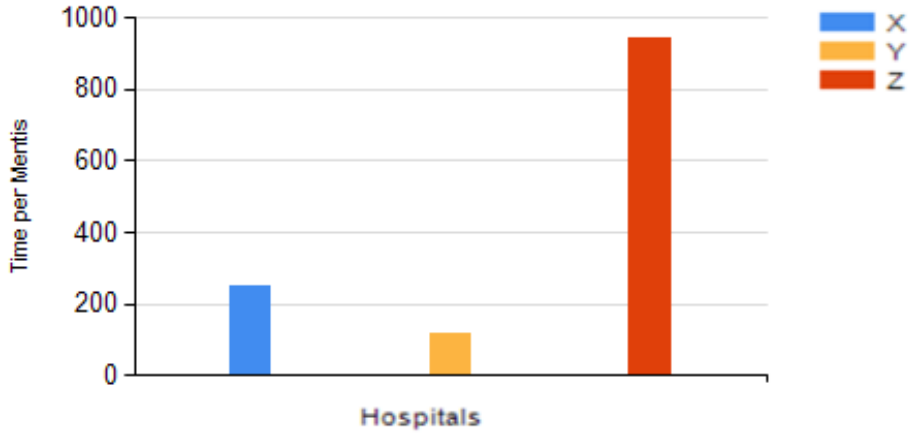


Figure 5-15 Hospitals Average Waiting Time

Figure 5-15 represent how implementation BI tools in the healthcare sector, to validate what is the less waiting time for getting the services, then represents that hospital (Y) is the lowest average waiting time to get services with 120 minutes per services and immediately followed by institutes (X) with 213 minutes and the highest average waiting service time is institute (Z) with average time 916 minutes per services.

After reviewing the average time of service and the average waiting time for each institution, and how this result is assessed, whether from the perspective of the institution or patients, they will be discussed after using the model to identify the average waiting time for four selected services, from the laboratory, to determine the waiting time until the patient receives the result of the test carried out by him, in the unit of the laboratory, and this is what the following results are shown for each institution separately.

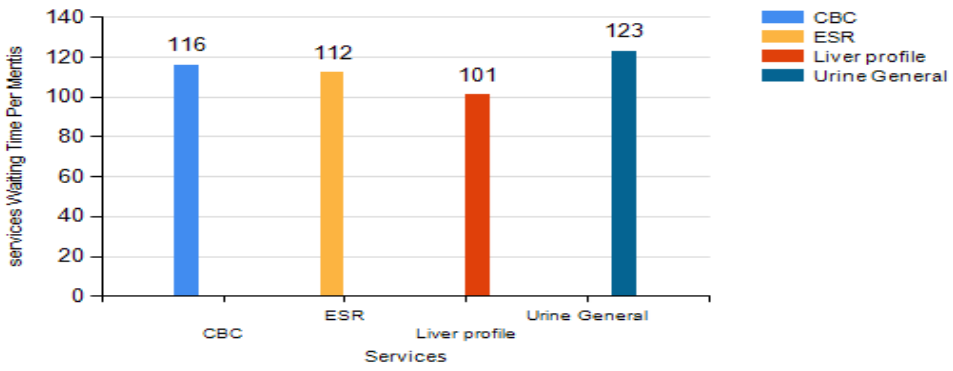


Figure 5-16 Laboratory Average Waiting Time on (X)

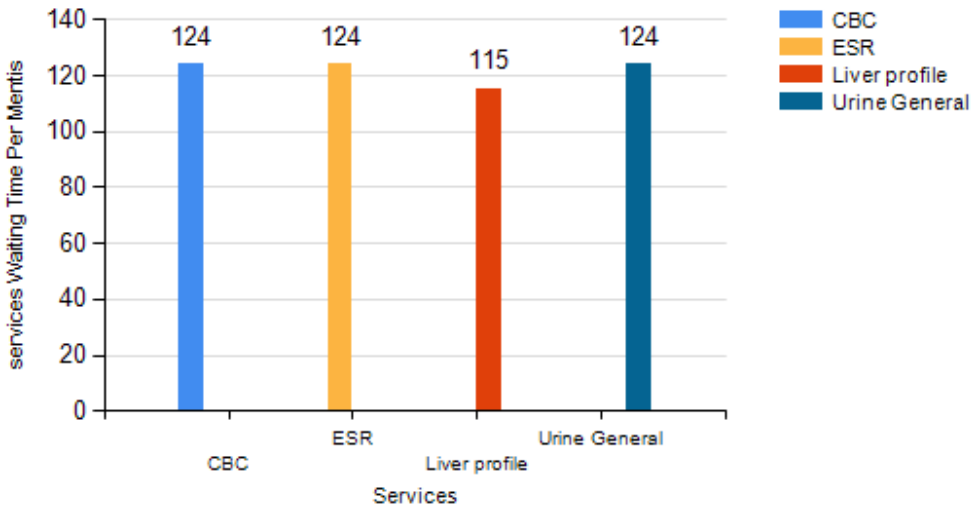


Figure 5-17 Laboratory Average Waiting Time on (Y)

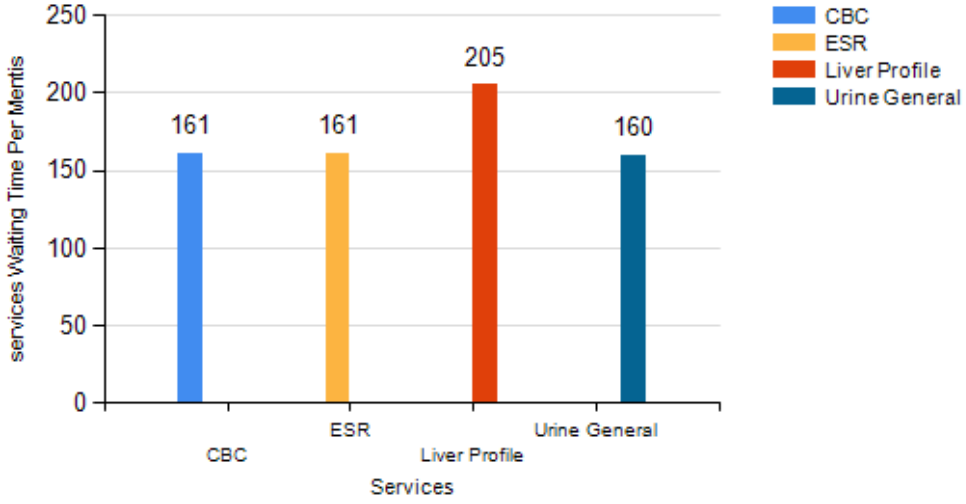


Figure 5-18 Average Waiting Time on Laboratory Department (Z)

Figure (5-16) (5-17) (5-18) above is result represent inspired by the model, to show the effect of the implementation of BI in showing average waiting time for selection tests (CBC, ESR, Liver profile, Urine General) in the laboratory department for the three hospitals, to let the stakeholders spatial the patients to compering between the hospital through the minimum waiting time, when he fetish for the faster deliver services.

From the above, whether for the average service time per institutes or the average waiting time for each institute, as well as the average waiting time for four selected

services for the laboratory section and represent their results, then in the following section we shall discuss that result from tow perspective:

a. Hospitals perspective

Time management from the institution perspectives, time is a cost and a point of weakness in the labor market in terms of competitiveness, because the more waiting patient to meet with the doctor whenever there is an associated operating cost, whether electricity or cleaning or consumption of assets from chairs and others, as well as its reputation, is not good of patients and their accomplices from the length of waiting, especially waiting for laboratory tests or see the doctor. As well as the cost of high operating in surgical operations for the large operating expenses and medical consumables and operation of operating rooms also with its medical staff.

In addition, any institutes looking for a competitive advantage in the medical field, its priorities should be to reduce service time while maintaining quality at the same time. When reviewing the results of average service time and the average waiting time for any institutes and summaries it in the bellow tables:

Table 5- 5: Average Service Time and Waiting Time

Institutes	average service time	average waiting time
X	250	213
Y	117	120
Z	217	916

Table 5-5 resents the comparison between average service time and average waiting time for any institutes, that represent a variety of result, for example (Y) is not bad in average service time indicator but is bad indicators in average waiting time, and vice versa for the institution (X), but we can say the good impression that reflects the summary of the table is for the institution (Z) when discussing the time of services and waiting time from institutes perspective.

But the result bellow reflects in details for average waiting services selection from laboratory units in the table below:

Table 5- 6: Average Waiting Laboratory Selection Services

Service Selection From Laboratory Department	average service waiting time		
	X	Y	Z
CBC	116	124	161
ESR	112	124	161
Liver profile	101	115	205
Urine General	123	124	160

Table 5-6 resents the comparison of average waiting services represent the lowest waiting time in for nay services selection that institute (X), which means (X) is high degree competitive from the other institutes.

b. Patients Perspective

Time management from the perspective of patients is one of the main factors that affect negatively or positively the satisfaction of the patient by providing medical service to him, sometimes not only service time or waiting time is final measure from patient's perspective the correlation indicators is more efficient when we decided from patient's perspectives, but that shall also discuss it in more details in the discussion of correlation in the next paragraph. However, the result of the implementation of BI in the healthcare sector to evaluate the services time and services waiting time from patient's perspective can summarize in the bellow table:

Table 5- 7: Evaluate the Services Time and Waiting Time

Services Selection	average service waiting time		
	X	Y	Z
CBC	116	124	161
ESR	112	124	161
Liver profile	101	115	205
Urine General	123	124	160
average service time	250	117	217
average waiting time	213	120	916

Table 5-7 represents information about evaluating the services time and waiting time from patients perspective in the laboratory for any institutes as summarize results of time management from the patient perspective, accompanied by

something of the complexities, because the average waiting time is the minimum in the institution (Y), while at the same time if depending on the selection test policy, the institution (Y) is the minimum waiting time, so in this case, the model adds more than a case study option to give you the clearer picture, As will be noted in the paragraph that shall discussion the correlation, and by using Framework module we can compare between the result to determine what is the pest and result through the modules to check the results for the patients. that lead to say patient decided the facing to best institutes to delivered his service with the lowest average waiting time. from the patient's perspective.

After that we showed how to achieve minimize the time by using Framework models that create to validate efficiency of it in healthcare when implementing BI in Sudanese healthcare sectors, and how to achieve the benefits from the implementations, at the level of patients or at the level of institutions that working in healthcare sectors, for all case study either in providers management or services management or time management, we can clarify the benefit more broadly, when looking at more than one criterion, and compare the results obtained above with more than one case study with each other. he analysis of case study results in the chapter (6) represent how to improving healthcare sector by improving informed decision by using BI tools to support DSS, and achieving comparative advantage between hospitals that must be reflected patient service quality and so the cost of services, and service covered in on institute, and also the Framework result can help stakeholders decision-maker in the health care institute by the result of the case study that represents information through Framework models using three case study (providers management, services management, time management) each of them it has a subcase study with many perspective discussion results to represent dashboard information.

The result of the providers management case study it have three subcases (expenses and revenue, staff turnover), each of them represent the result from many perspectives, For example, if we take the Firstly department it can represent the result to serve the healthcare institutes managerial and shareholder, by exploring institutions financial position and situation either for selection department or in general for all financials year, to make a decision in terms of financial position, to assist in the development process by highlighting the position of weakness and

strength of units compared to revenues and expenses, and also compare them with the number of employees within the institution and their experience that drives the institution forward.

Secondly the subcase study staff turnover reflects the job satisfaction indicators to measured stability of institution spatially in the healthcare sector because is reflected positively or negatively on the medical service quality provided by employees with full loyalty to the institution, and patients satisfaction perspective. So it is necessary when we refer to the providers management within the medical institution must be seen from several angles, one of these main angles must be represented by BI tools, what is the frequency of resignations and separation and appointment within the healthcare institutions, in this subcase study the beneficiaries of the results of the analysis and BI dashboard is the institution and the community, because the good institutions are evaluating its employees and motivate them by achieving job satisfaction, and qualifying them to limit their leaving its works, that reflected in the patient's satisfaction.

The result of the services management case study it has three subcases (services coverage, services cost, institutes cost), the beneficiaries in the first place are the patients who can view the services available in any healthcare institution and what are the services prices, and comparing them with other institutions and then identify the destination. The models result from dashboard represent the availability of units or department like (orthopedic or Gynecology obstetrics.etc) in any institutes and what the services available or not on them, before determined has path to what institutes coverage all its service’s needs, and the coverage insurance contract for any healthcare institutes, and represent also patient’s frequency and its percent of the insurance company in any institutes to serve either the patients or institutes managers. The Secondly sub case study services cost, that one of model advantage is the patients can see the comparison of prices between any healthcare institutes using and implementing BI and its tools to enhance informed decision, that comparison of the prices to determine the patient's destination for service with regard to the quality of service, also the decisions determined based on several factors, including patient satisfaction and time factor, the dashboard result represent the average service cost for each institute to the patients, and average services cost versus Services coverage for any institutes, either to selected services on department

or all services that from patients aspect dashboard. But from the institute's perspective, the service cost is a double-edged sword. when the cost of services is affordable to patients, then they have height frequencies, which in turn increases the revenue of the institution and makes the institution the same competitive advantage for its peers, but also reduces revenue compared to expenses if there is no balance.

The result of Time management case study it has two perspectives either from institutes or the patients, the time is a more important factor in measuring the effectiveness of institutions that delivered any services, as well as the quality of services. and so the framework models represent the average services time and services waiting time to get patients satisfaction, in addition, the waiting to receive the service, that is means more consumption of assets such as sitting chairs, for example, in addition to electricity and cleanliness, as well as the patient's resentment of waiting, reflected negatively on the reputation of the institution. in the emergency, for example, may save the life of a patient by the fast response.

In this case, the study represents how to use BI tools in healthcare sectors, to achieving minimize patient waiting time when deliver is services, to be satisfied from institutes policy, that reflect the efficiency of care, then we can be divided meager of time form several perspectives and comparing between the institutes and who is less average waiting time and so average services time.

5.5. **Multifaceted Case Study Result**

Here we will correlate "interesting/important correlations" in increasing difficulty showing the possible deepness of BI analysis, that presented above in the analysis of each case study and sub-case study, and that is through, discuss more than one case study either from the perspective of patients or institutes and determine who are the beneficiaries of these results(Patients, Community, city, institutes, ministry of health, stakeholders, government, medical suppliers, medical insurance company) to make accurate decision based on information that summarizes from historical and huge data, according to demand and the need for decision-making:

5.5.1. Single correlations inside the sub-use-cases:

As previously described in case of study Chapter(6) the researcher selected three case study to represent through it how improving informed decisions based on the implementation of Business Intelligence technology in healthcare sectors, and for each case study divide to more than one sub-use-cases that have perspectives describe indicators, to represent the BI system easy to implement and use in the Sudanese healthcare industry and does it achieve our goals, and prove the BI model is necessary for making decisions in the Sudanese healthcare industry to achieve benefits either to the patients or a community, or institutes and other actors that related by this sector, based on identification and preparation of data that gathered and restorations in the same format.

At the flow, we can represent the correlation and explore the single simple correlations inside or across the sub-use-cases and determine how is become beneficiaries from this analysis.

The indicators represent through the sub-use-cases department the correlation between revenue and expenses of selection seven common departments designate the relationship between revenue and expenses on the institutes to seven department selection, that result can be summarized at the table and table below:

Table 5- 8: Relation Between Revenue and Expenses For Particular Departments

Departments	**Revenue Percent**			**Expenses Percent**		
	Hospitals					
	A	**B**	**C**	**A**	**B**	**C**
General Surgery (102)	0.47	6.38	52.61	8.58	12.68	47.82
Orthopedics (103)	7.22	61.15	1.16	0.00	50.68	0.32
Pediatrics (104)	0.02	1.62	0.16	0.05	5.85	0.36
Internal Medicine (105)	56.77	5.96	2.35	7.02	8.17	5.98
Obstetrics & Gynecology(106)	0.05	9.09	2.37	0.69	11.84	1.55
Laboratory(202)	0.11	6.81	6.93	50.70	1.40	19.54
Radiology (201)	35.34	8.98	34.42	32.96	9.39	24.43

Table 5-8 represent the result of the correlation between the revenue and expenses for each institute in the seven common selection department, that can be represented to the institute's manager or shareholder when implementing the BI tools to serve

the hospital with their stakeholders, it's manger to make the balance between the expenses and its revenue, the figure dashboard serves the manager and stakeholder to make a decision based on historical data, what is the highest department selection revenue and what is the lowest revenue, and what is the loser department, and how can manage it by looking at what weaknesses made this department less profitable, to avoid them in the future.

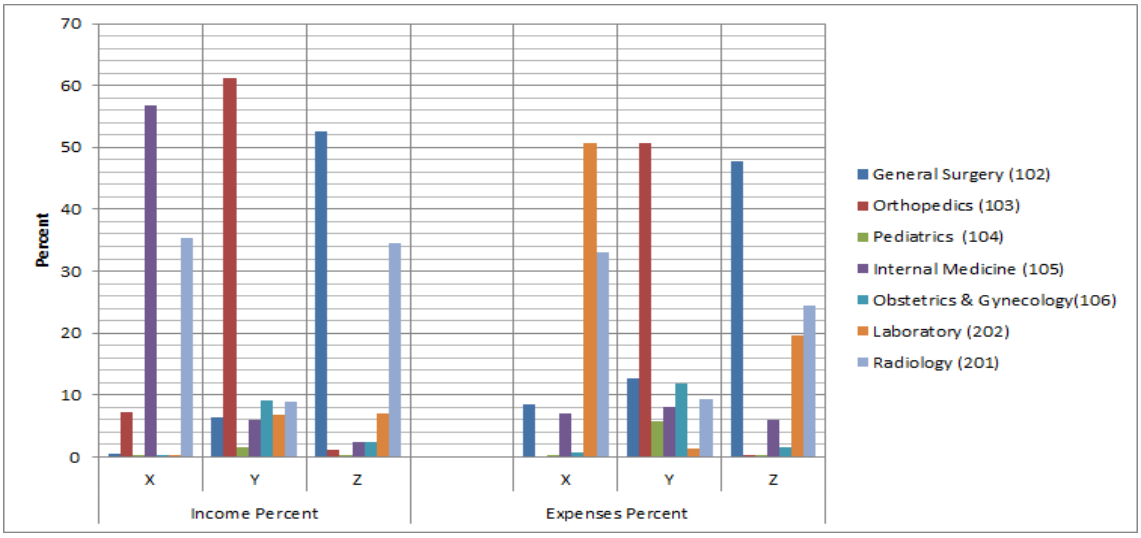


Figure 5-19 Relation Between Revenue and Expenses For Particular Departments

Figure 6-19 represent the result of the correlation between the revenue and expenses for each institute in the seven common selection department, that can be represented to the institute's manager or shareholder when implementing the BI tools to serve the hospital with their stakeholders, it's manger to make the balance between the expenses and its revenue, the figure dashboard serves the manager and stakeholder to make a decision based on historical data, what is the highest department selection Revenue and what is the lowest revenue, and what is the loser department, and how can manage it by looking at what weaknesses made this department less profitable, to avoid them in the future.

a. In sub-indicators inside the sub-use-cases Department the correlation between revenue of selection seven common departments and number of staff indicators, represent how the using implementation of BI tools serve the institutes and its managers and stakeholders, by determining what the relation between the number of staff and the department revenue for any institutes, and then after determining

between them mangers cam decide if the revenue base on the quantity of staff with its the qualification or the quality of staff take into account the experiment and qualification and its training, all of this factors help to accurate decision besides the dashboard that creates by implementation BI in healthcare institutes, the result of the relation above it can be summarize at table and dashboard figure below:

Table 5- 9: Correlation Between Revenue For Particular Departments and Staff

Departments	**Revenue Percent**			**Number of staff**		
	Institutes					
	X	**Y**	**X**	**X**	**Y**	**Z**
General Surgery (102)	0.47	6.38	52.61	**1260**	**604**	**449**
Orthopedics (103)	7.22	61.15	1.16			
Children (104)	0.02	1.62	0.16			
Internal Medicine (105)	56.77	5.96	2.35			
Obstetrics & Gynecology(106)	0.05	9.09	2.37			
Laboratory(202)	0.11	6.81	6.93			
Radiology (201)	35.34	8.98	34.42			

Table 5-9 represent the correlation between the revenue and expenses for each institute in the seven common selection department with number of staff, that can be represented to the institute's manager or shareholder when implementing the BI tools to serve the hospital with their stakeholders, it's manger to make the balance between the expenses and its Revenue against staff number.

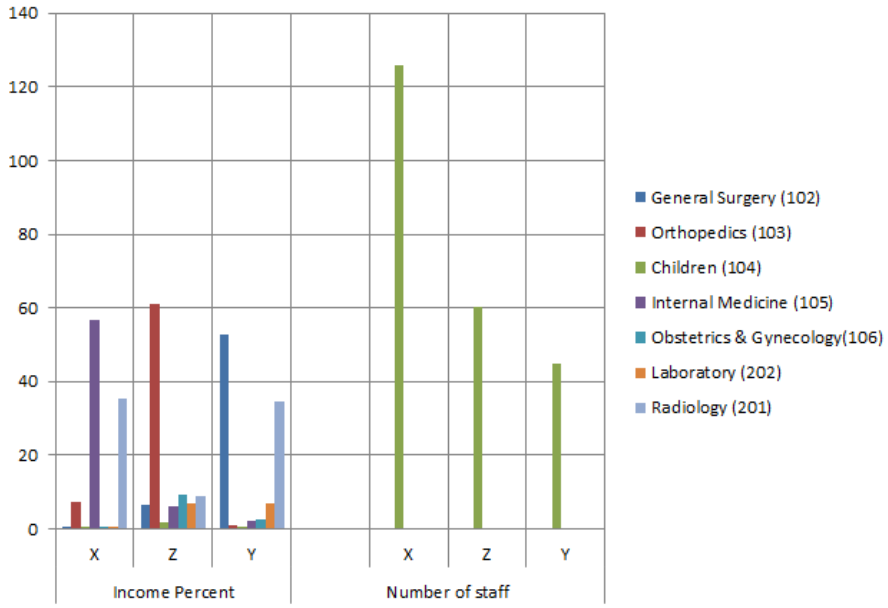


Figure 5-20 Correlation Between Revenue For Particular Departments and Staff

Figure 5-20 represent the correlation between the revenue and expenses for each institute in the seven common selection department with number of staff, that can be represented to the institute's manager or shareholder when implementing the BI tools to serve the hospital with their stakeholders, it's manger to make the balance between the expenses and its revenue against staff number.

The correlation result between revenue of selection department and number of staff in the institutes , represent what the relation between perspective of sub indictors Revenue and number of staff, and is the quality of human resource effective directly or in directly on the institutes Revenue ,or the qualification and training effective more than quantity, take into account quality of staff ,all of this perspectives the institutes manager, explorer this result of information based on historical data when using implementation of BI tools in healthcare sector, then the dashboard of relation between Revenue and number of staff in the institutes it can serve the institutes and its managers or its stakeholder to make accurate decision is the expedition of staff reflect positively or negatively in the Revenue of institutes, and also it can serve the city and society that staff belong to it, either form economic perspective or employees jobs opportunity, Furthermore it can reflect and serve also the patients when the decision of relation base on qualification and quantity and experiences,

that reflect on the type of services that delivered to the patients to achieve its satisfaction after delivered its services by good staff.

b. In a sub-indicator expenses and revenue, the correlation between revenue and expenses of all operational transaction of in the institutes represent when institutes implementing BI tools, how to serve institutes manager to make a good decision based on real information that represents the financial situation of institutes to reflect the current and future financial position, and what is predictable, that summarize on table and Figure below:

Table 5-10: Correlation Between Revenue and Expenses

Institutes	Revenue Percent	Expenses Percent
X	39.36	52.08
Y	25.70	22.20
Z	34.94	25.72

Table 5-10 represent the correlation between the revenue and expenses for each institute at general perspective to captured the financial situation for the healthcare institutes, that can be represented to the institute's manager or shareholder when implementing the BI tools to serve the hospital with their stakeholders, it's manger to make the balance between the expenses and its revenue as general financial position.

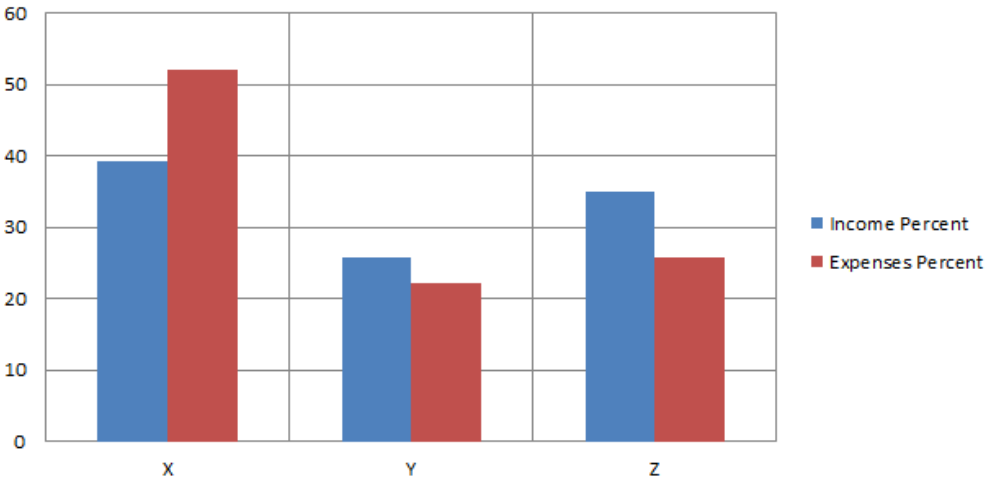


Figure 5-21 Correlation Between Revenue and Expenses

Figure 5-21 capture the correlation result between revenue and expenses, represent what the relation between the perspective of sub-indicators revenue and expenses,

by using the implementation of BI tools in the healthcare sector, to serve the institutes to make the accurate decision is that related by institutes financial situation, and also serve the stakeholder by determining what the trend of our business, and so that they can plan properly so that the organization is more profitable, that is reflected in the quality of the service provided and the reputation of the institution and job satisfaction of staff, which in the term is reflected in the satisfaction of patients.

From the above, we can say that whenever the management of the institution can help in deciding by making the institution financially stable, many actors benefit from this stability.

d. In a sub-indicator **Expenses and Revenue,** the correlation between Revenue and expenses virus **efficiency** of all operational transaction of Revenue and hospital efficiency in the institutes represent by implementing BI tools in the institutes that result what the relation between and to factors virus frequency of patients, which in turn contains several indicators, for example, institutes manager perspectives or city medical suppliers, patients, communities, governmental, all of that actors serve to make good decision based on real information that represents the relation between hospital frequency of patients, each according to his point of view on which he wants to base the decision that summarizes on table and Figure represent the graph of that table after divided patients frequency to thousand to create readable dashboard below:

Table 5- 11: Correlation Between Revenue and Expenses versus Efficiency

Institutes	Revenue Percent	Expenses Percent	Frequency of patients
X	39.36	52.08	59399
Y	25.70	22.20	26502
Z	34.94	25.72	149647

Table 5-11 represent the correlation between the revenue and expenses for each institute with the patient’s frequency factors, that can be represented to the institute's manager or shareholder when implementing the BI tools to serve the hospital with their stakeholders, it's manger to make the comparing between the expenses and its Revenue against patient’s frequency.

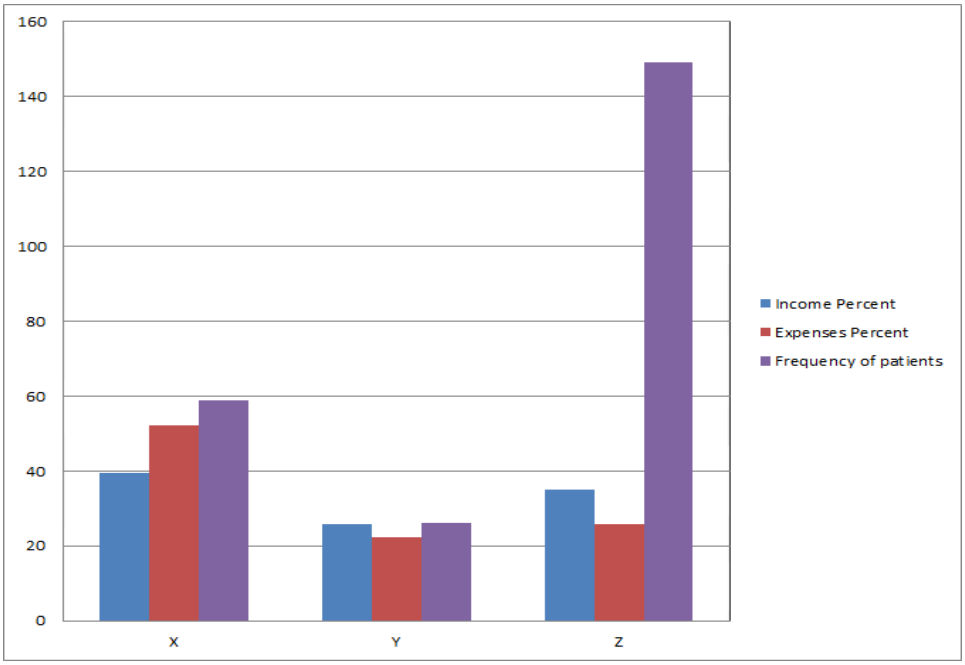


Figure 5-22 Correlation Between Revenue and Expenses versus Efficiency

Figure 5-22 represent the correlation between the revenue and expenses for each institute with the patient's frequency factors, that can be represented to the institute's manager or shareholder when implementing the BI tools to serve the hospital with their stakeholders, it's manger to make the comparing between the expenses and its revenue against patient's frequency.

The correlation result between Revenue and expenses virus hospital frequency of patients, represent what the relation between the perspective of sub-indicators Revenue and expenses and efficiency, to serve the institutes to make the accurate decision is that related by institutes financial situation, and also serve patients by gives indicators of hospital frequency and its price when correlated with Revenue and hospital, and also from the point of view of expenses, for the development and training of staff, which leads to improving the service of the hospital environment that reflect the patients and community that serve its patients and get its satisfaction in that institutes it has a high frequency that creates indicators that mean good reputation that also lead to improving the service.

e. In a **sub**-indicator **Expenses and Revenue** the correlation between doctors efficiency and **efficiency** of hospital ,that determined comparative clinic of each hospital in the institutes , that result represent what highest clinical patients

frequency and how is highest physician in that clinics compared with the general frequency of the hospital and the number of patients they are visit clinics, by using BI tools in the institutes ,the beneficiaries of this result and dashboard at the first the institutes manager that needs to make good decision based on real information that represent what is his active clinics It has a good reputation for patients and how is the physician that highest, that means many perspectives for the institutes and also from patients perspectives determine what is best clinics in any hospital and compared between them base on this result, and also create comparative advantage between the hospital ,lead to the benefit of patients , and to develop the medical service provided. as we can show that at Figure and table of the summary below after divided clinical and patient's frequency on thousand go readable dashboard:

Table 5- 12 Correlation Between Physicians Efficiency and Hospitals

Institutes	**Clinics**	**Clinics Percent**	**Highest Doctors Percent**	**Clinics Frequency of patients**	**Frequency of patients**
X	Medicine	28.88	51.77	17154	59399
Y	Medicine	33.01	29.44	8748	26502
Z	Medicine	35.32	99.62	52850	149647

Table 5-12 represent the correlation between the Physician efficiency and clinics frequency for each institutes with the patient's frequency factors, that can be represented to the institute's manager or shareholder when implementing the BI tools to serve the hospital with their stakeholders, it's manger to make the comparing between the doctor's efficiency and patient's frequency.

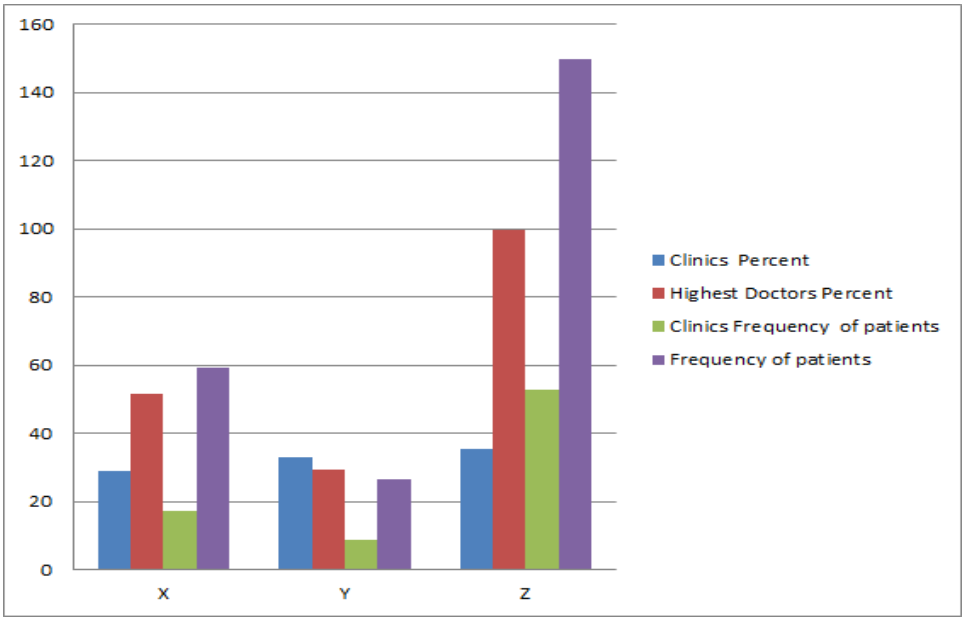


Figure 5-23 Correlation Between Physicians Efficiency and Hospitals

Figure 5-23 represent the correlation between the doctor's efficiency and clinics frequency for each institutes with the patient's frequency factors, that can be represented to the institute's manager or shareholder when implementing the BI tools to serve the hospital with their stakeholders, it's manger to make the comparing between the doctor's efficiency and patient's frequency.

As described the correlation result between doctors efficiency, and efficiency of hospital frequency by patients, serve many actors that related by the cycle of the process in the healthcare sectors start from the institutes that needing to make accurate decision to attract patients to its clinics to be the highest frequency to reflect on its Revenue and to make it on the top situation in any clinics the needed to be competitive advantage between another hospital, and also serve patients by gives indicators of hospital efficiency and outpatients clinics efficiency that lead to them what is the pest clinical and doctors and where is going to get professional service and in the famous doctors, all of them reflect the patients and community that its patients get the highest quality of services it came from the competition between hospitals.

f. In a **sub-indicator staff turnover** the correlation between employees turnover for each hospital and jobs types taking into account the Turnover Types, to highlight the job satisfaction of the employees in each institution, that result gets

by implementing BI tools in the institutes to serve institutes manager to make a good decision based on real information that represents jobs satisfaction in its institutes to get points on the strength of excellence between another hospital that summarizes on the table below:

Table 5-1 Correlation Between Staff Turnover Per Jobs types and Turnover types

Job Types	**Institutes turnover**			Turnover Types			
	X	Y	Z	**Resignation**	**Under experience**	**Arbitrary**	**By violation**
Account	2	10	1	A			
Administrative	7	23	7	**354**	**18**	39	11
Consultant	2	129	6				
Doctors	17	324	18	B			
Employees	32	255	16	**1795**	-	-	-
IT	6	7	0				
Nurse	247	707	26	C			
Operator	62	185	28	**84**	**26**	8	12
Technician	28	155	28				
Total	403	1795	130	2233	44	47	23

Table 5-13 represent the correlation result between employees turnover for each hospital and jobs types taking into account the Turnover Types, serve the institutes to make an accurate decision is that related by employees job satisfaction, that reflects indirectly with services of patients if there is no satisfaction of jobs reflected on the services delivered by that employees it has no satisfaction, and also serve patients by gives indicators of hospital efficiency of services delivered, and also the separation or turnover by arbitrary or under experience reflect the society because that process make some employees unemployed, which negatively affects society and the city at the same time.

g. In case study medical **coverage and** a **sub-indicator Services coverage and Insurance coverage** the correlation between the number of **Services coverage** base on the department or unites coverage and **Insurance coverage** in the hospital, that make a competition between healthcare institutes form one to another then lead to serve the patients because any institutes try to attract the

patients by providing all services to the patients that needed to it to achieve patients satisfaction, and also reflect the patients how many insurance coverages at any institutes too, all that result answered the question above it is shown in the figure and summarize of the table below:

Table 5-2 Correlation Services Coverage and Insurance Coverage

Department	Institutes		
	X	Y	Z
Outpatient Clinic	227	89	148
Radiology	499	292	448
Lab	1383	214	206
Department coverage	20	17	16
Insurance coverage	24	42	39

Table 5-14 captured the result of medical coverage as the sub-indicator Services coverage and Insurance coverage the correlation between the number of Services coverage base on the department or unites coverage and Insurance coverage in the hospital, to make a comparison between healthcare institutes form one to another then lead to serve the patients because any institutes try to attract the patients by providing all services to the patients that needed to it to achieve patient's satisfaction.

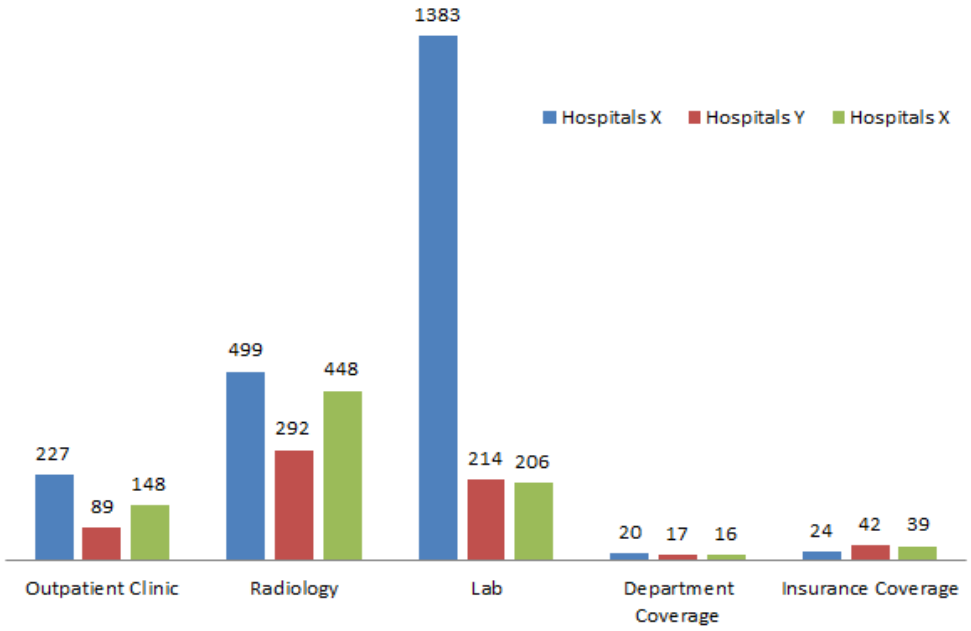


Figure 5-24 Correlation Services Coverage and Insurance Coverage

Figure 5-24 captured the result of medical coverage as the sub-indicator Services coverage and Insurance coverage the correlation between the number of Services coverage base on the department or unites coverage and Insurance coverage in the hospital, to make a comparison between healthcare institutes form one to another then lead to serve the patients because any institutes try to attract the patients by providing all services to the patients that needed to it to achieve patients satisfaction.

The correlation result between servers coverage in the selection common department at any hospital, and the number of department or units that deliver services in any hospital that reflect how many specializations in the hospital to serve the patients, and also serve the institutes to make an accurate decision is that related by institutes competitive by getting many clinics specializations to be unique units or not share this services in that units with another hospital, and also serve the city that service is available at it, without needing to migration to get services in another city, if is it available by gives indicators of hospital efficiency from point of view of services coverage, that to be reflected also on the society by getting many services available on its city to make their patients get services easier and also serve traffic load by minimizing the movement from hospital to anther when thy fetish to services.

5.5.2. Multi correlations between the sub-use cases

In this section, we shall discuss the correlation between sub-use case study and other across the case study to reflect how to extracting information from huge data and viewed from several angles and measured from several indicators, to enhancing strategic decisions based on the dashboard information that get from implement BI in the Sudanese healthcare industry. that decision it can make either by institutes or patients or other actors related to this healthcare field, both from his point of view and his need for the information to be decided upon. for example, the patients needed to know what the minimum average service cost across the highest average service coverage, and take into account good services with the less waiting time. and so the medical supplier focus on the witch department is the highest frequency and in which institutes to determine the demand of its consumable or her medications marketing. on the side, the institutes focus on achieve patient satisfaction, by seeking to reduce their cost and to be unique in a particular discipline.

To get job satisfaction for employees to be positively reflected on patients, and so the government and community they are seeking that medical service is available and affordable for patients. and all of the institutes is seeks to provide distinguished service and stable financial and functional, that also reflect on the community and city that staff of institutes belong to it. The correlation between the number of **Services coverage** and **patient's frequency** in the hospital, that make a highlight the relation between **the efficiency** of the hospital, and also the relation between insurance company coverage with that sub case study indicators, that result represent at Figure and table below:

Table 5- 3 Services Coverage and Patients, Insurance Frequency

Institutes	**Services coverage**	**Insurance Frequency of patients**	**Insurance Frequency Percent's**	**Frequency of patients**
X	499	21395	24.94	**85787**
Y	292	99331	32.75	303279
Z	448	34672	66.06	52489

Table 5-15 represents the information though implementation BI framework in healthcare sector on data that it collected from three institutes the relation between

Services coverage and insurance frequency, beside the relation between the frequency of patients payable.

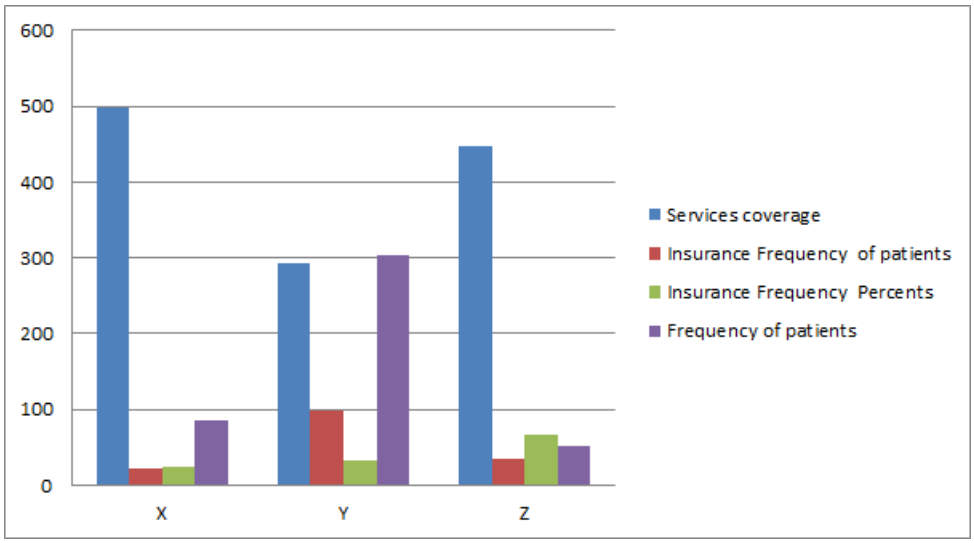


Figure 5-25 Services Coverage and Patients, Insurance Frequency

Figure 5-25 represents the information though implementation BI framework in healthcare sector on data that it collected from three institutes the relation between Services coverage and insurance frequency, beside the relation between the frequency of patients payable.

The correlation result above that represent either by table or figure it reflects how many patients come to get service in the hospital and what is the type of patients is it played for hem self or with insurance medical company, all these indicators serve either the hospital distinguish between the relation of service and the efficiency of institutes, and also what is the relation by the insurance company and both services coverage and frequency of patients indicators, and also serve patient because when he finds there needs of services in one hospital without needing to migration between two or three hospitals to complete its treatments, that lead to him the services satisfaction indicators, city and also it serves when the patients not needing to travel between many cities to get their treatments from traffic road perspectives, society or a community also reflect with patients satisfy -from the hospital that belongs to them.

a. The correlation between the number of **Services coverage** and **average service time** and **the average waiting time compared with the services cost either**

total services or average services cost in the hospital, that makes highlight the relation between **the efficiency** of the hospital and the relation between four sub case study that mentioned above, to explorer dashboard indicators for the hospital managers and the patient and the ministry of health that report to the government, each makes its decisions according to information from sticking from his own point and the situation in which he wants to decide where that result represent at the table and figure below :

Table 5-4 Services Cost and Waiting Time and Coverage and Frequency

Institutes	Services coverage	Total service Cost	average service Cost	average service time	average waiting time	Frequency of patients
X	499	93828.32	22.17	250	213	**85787**
Y	292	79955.16	53.23	117	120	303279
Z	448	39579.52	24.19	217	916	52489

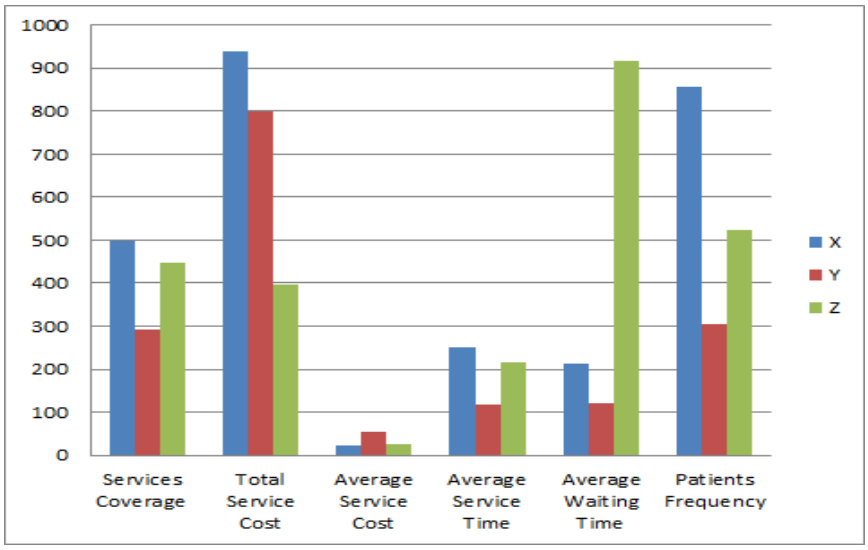


Figure 5-26 Services Cost and Waiting and Coverage and Frequency

Figure 5-26 illustrates the services management factors including Service availability, Average service time, Patients frequency Average service cost, and Average waiting time. These factors were selected to demonstrate the effectiveness of the framework in analyzing, correlating and comparing different variables to expose their complex interrelationships.

For example, from the hospital administrator's perspective, service cost is a double-edged sword. Because when the cost of services is affordable to patients, they tend

to have height frequencies, which in turn increases providers' revenue. This leads to providers having a competitive advantage over their peers, but simultaneously it reduces revenue and is likely to lower the quality of service. From this scenario, Fig.4, indicates that provider X delivers the most services, followed by provider Z, and then Y. The figure also shows that the average service cost for provider's X and Z are lower than Y, while they deliver more services. This suggests that maybe provider Y administrators need to reevaluate the costing and pricing of their services, and possibly identify cost-saving measures. Additionally, Fig.4 indicates that higher frequency of patients corresponds to higher average waiting times at the three providers while provider X in particular needs to pay close attention as its average waiting time does not conform with the other two providers.

The correlation result between servers coverage and **average service time** and **average waiting time and** patients frequency and **average service cost**, that result represent the relation between the services coverage and the **average service time** from side , and **average service time** On another hand with its average services cost, to reflect line of services delivered at three institutes the subject of study from several perspectives, and several angles particularly patients who are concern to affordable cost, with available services coverage, with highest quality when its deliver, without long waiting to get its services, all of this perspective became indicators to patients satisfaction which create good reputation to the institution, It leads patients to increase the frequency, which is reflected to on the cycle of financial Revenue, if seen to waiting from patients perspective, but when is seen from institutes perspective the waiting is an increase in expense whether at the level of cleanliness, or electricity consumption, or consumption of assets, and most importantly, the whole level of patient satisfaction , which is negatively or positively affected. then we can say this result serve patients and hospitals and its managers or stakeholders.

b. The correlation between the number of **Services coverage** and **Revenue** in the hospital, that makes a highlight the relation between **Services coverage** in the hospital and sub-case study **Administrative Expenses and Revenue**, to give indicators for the hospital managers besides perspective of the number of staff take into account the effectiveness of services cost in each hospital on the

Revenue and expenses or the manpower, that result represent at table and Figure below:

Table 5-5 Services Coverage and Cost and Revenue and Expenses with staff

Institutes	Services coverage	Total service Cost	average service Cost	Revenue Percent	Expenses Percent	Number of Staff
X	499	93828.32	22.17	39.36	52.08	**1260**
Y	292	79955.16	53.23	34.94	25.72	**604**
Z	448	39579.52	24.19	25.70	22.20	**449**

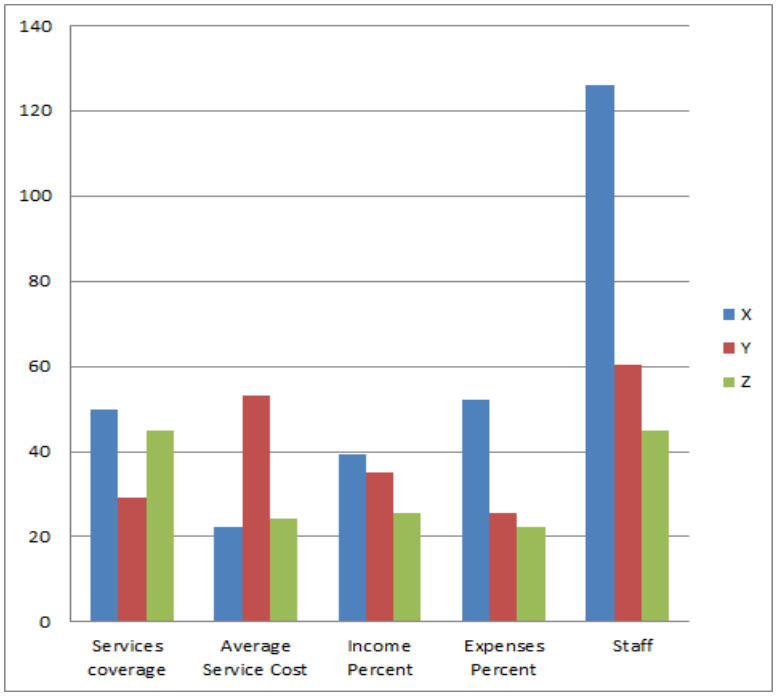


Figure 5-27 Services Coverage and Cost and Revenue and Expenses with staff

Figure 5-27 and Table 5-17, is refers to providers' cost management, including service cost and average service cost. also clearly demonstrates the relation between the average service cost and service availability, and the revenue and expenses percent.

The correlation result between servers coverage and sub case study expenses and revenue , that result represent the relation between the services coverage and the revenue from side , and expenses on another hand, all of this perspective became indicators to hospital manager , to make accurate decision, based on the relation between that sub indicators by getting that result after implementing BI tools in its

institutes, to serve its hospitals base on the dashboard result to answer the questions what the relation between manpower and services coverage from staff utilization perspectives, and in contrast the relation between expenses and manpower perspectives against service coverage to make breakpoints from the side of operational cost of institutes , that effective directly on the Revenue of hospital ,and implicitly effect on going concern of institutes ,that reflect on the quality of services , then we can say the beneficiary of that dashboard the institutes and its managers and stakeholder, and also community and its city that reflect if the institutes effective on its services either quality or quantity, It can be said that impact and benefit are directly proportional to stakeholders or actors on the framework models either internal or external.

5.5.3. Multi-Layer Correlation between a case study and case study

The correlation between case study in the hospital, by using BI tools gets dashboard to manager or institutes stakeholders, to help them to make a good decision based on summarize information that extracts from the huge data either formatted or not, restructure that data collected in an un useful way.

The result seen in graphics below represent the relation between case study and to other implicit the interaction of factors of the sub case study of any institutes:

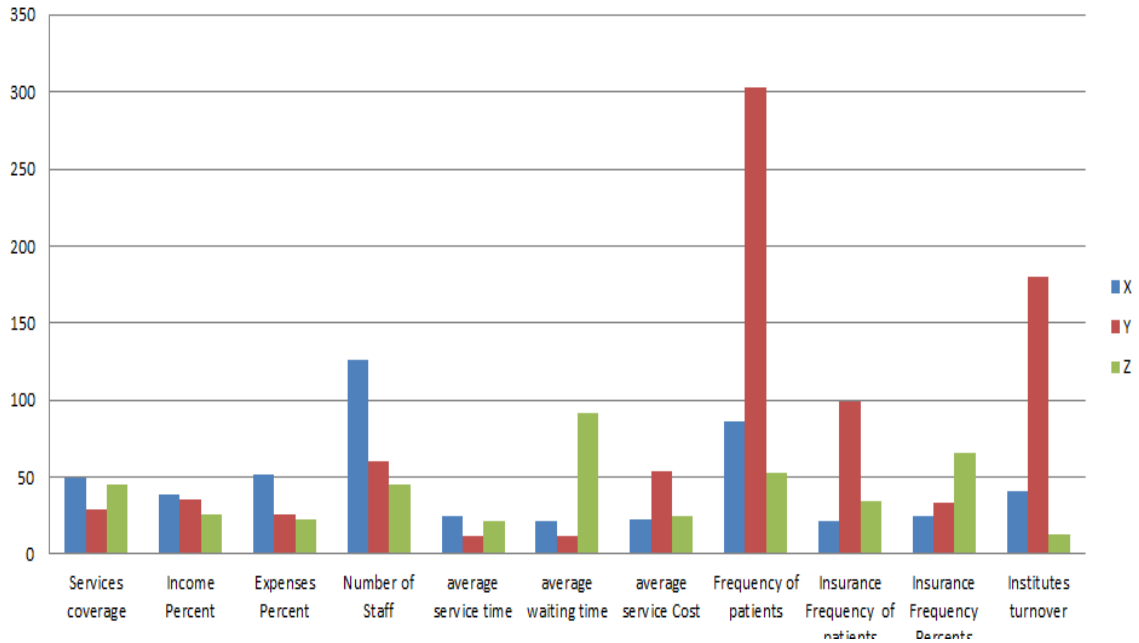
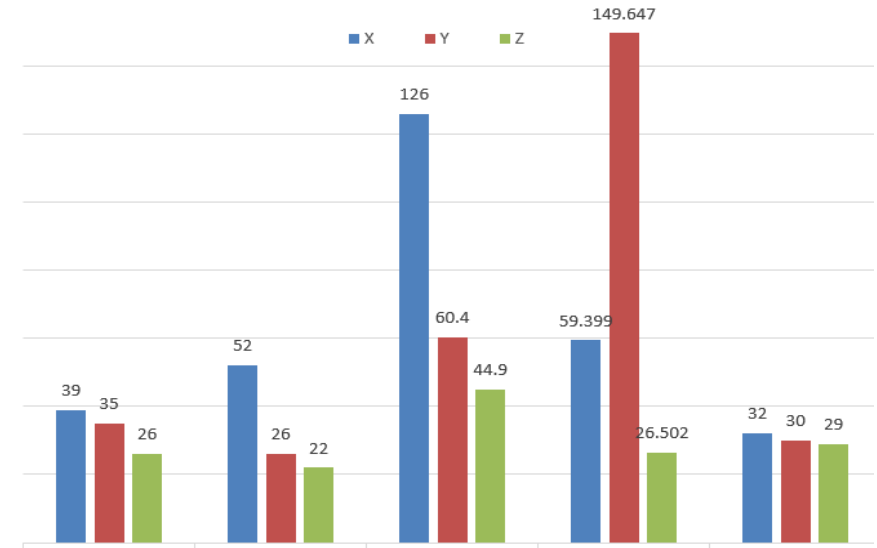


Figure 5-28 More complex correlation between a case study and case study

Figure 6-28 represents the result that shown above are considered as dashboard for institutes manager or stakeholder decision-maker, to analyses its situation and make an accurate decision, based on summarized information in general situation, by cross-correlations for each factor and perspective either between case study to another case study or between case study and other perspectives, taking into account the measurement using, then we can say base on the result above, The BI Tools can reflect information to the decision-maker for many types of perspectives on the institutes, It can be discussed in detail in the following:

1. What the relation between services coverage and the number of staff, by determine is the coverage of the services based on the quantity of staff or qualification?
2. Is the number of services converge related by patient's frequency, or both services coverage and average waiting time it has related to frequency?
3. Is the main perspective of patient satisfaction is majored by patient frequency, or whether it is influenced by specialization and uniqueness in a particular discipline?
4. what is the relationship between average services time and the number of staff, and to what extent reflected on the patient's satisfaction? Is the number of staff reflecting on the expenses percent of Institutes?
5. To what reflected of Staff turnover on the satisfaction of patients and also reflect of it from financial Perspective patient's frequency.
6. What is the relation between patient satisfaction from reducing service cost perspectives and institutes Revenue across the patient's frequency?
7. To what extent is reflected reduce the cost of services to get the satisfaction of patients and high frequency of patient, on the other side, it does not adversely affect the Revenue and reduce profits and increase expenses so as not commensurate with the revenue.
8. To what extent provided and serve the community, by providing affordable services to its patients, that provide him by the greatest number of services we can be called it high availability of services so that patients find all the services in one location and quality appropriate to their health.
9. what the relation between insurance company contract and frequency of patients and also to what extents is reflected insurance on the Revenue and expenses.

The conclusion of all questions above represent the implementation of BI in Sudanese health care institutes serve many actors related to this sector either patients that represent the cornerstone of this cycle or stakeholders or the community or all governmental level via the Federal Ministry of Health, all of it needs comprehensive report to make the good decision for strategic planning, coordination, and harmonization of all health actors'. To gets the main objectives of Its institutes developed.



	Revenue /Y	Expenses /Y	Staff	Patients	Turnover
X	39	52	126	59.399	32
Y	35	26	60.4	149.647	30
Z	26	22	44.9	26.502	29

Figure 5-29 Administrators' dashboard 2015-2018

Fig.5-29 illustrates the provider administrators' dashboard investigating the correlations between the critical factors shown, i.e., providers' financial position, Patients' frequency, Staff, and Turnover. The units in Fig. 6-29 are as follows: revenue and expenses are in thousands of Sudanese Pounds (SDG), while Patients frequency is in thousands, and Staff in hundreds, and finally Turnover is a percent of the total staff for the study period.

The dashboard in Fig. 5-29, is one of many available to hospital administrators and their shareholders that are created based on KPIs they have identified. The revenue, number of staff, and the frequency of patients reflect the level of operation of the hospital and affect patient satisfaction. Turnover is directly impacted by staff satisfaction with their jobs and level of affiliation to their employer. As discussed in

the provider management group of factors in the previous section, patients' and staff satisfaction have direct bearing on the revenue.

It is clear from Fig.5-29 that provider Z has the highest Turnover during the study period, since 32% of their staff have left the organization. This may indicate that staff are poorly selected, trained, or are complacent, and maybe underpaid, and that further detailed analysis of this factor is required.

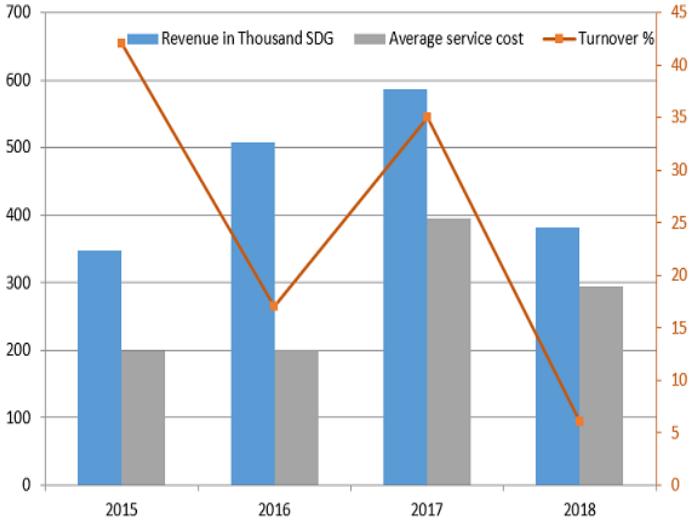


Figure 5-30 Provider Y management dashboard

Fig. 5-30 shows the result of a drill down into provider Y focusing on Revenue, Average service cost, and Turnover between 2005 and 2018. These factors were selected to demonstrate the effectiveness of the framework in analyzing and exposing the correlation between them. Administrators explore trends through the years to try to explain their institutions' performance, for instance, the revenue drop in 2018, and turnover spikes during 2015 and 2017. It's clear from Fig. 4 that during 2015 to 2016 the average service cost was consistently reasonably priced for patients at about 200 SDG. Staff turnover was extremely high in 2015 at around 47%, indicating that staff morale and job satisfaction were low. It's interesting to realize that during 2016 turnover dropped to around 17% without affecting the average service cost, and so provider Y was able to achieve its target of high revenue with less turnover. However, in 2017 competition in the healthcare market lead to high turnover and reductions in the average service cost and this was reflected on the provider's revenue. All these developments in turn lead to reducing turnover and improving staff's job satisfaction as seen in the figure.

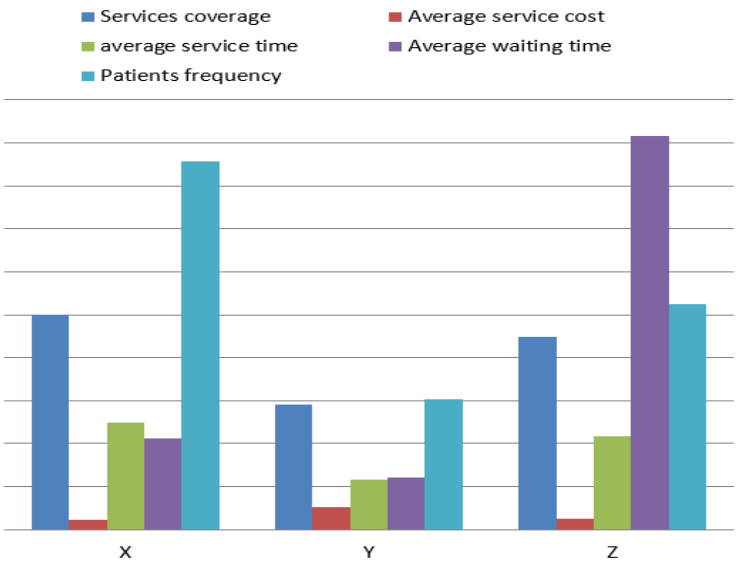


Figure 5-31: Services management dashboard

Fig.5-31 illustrates the services management factors including Service availability, Average service time, Patients frequency, Average service cost, and Average waiting time. These factors and their many interrelationships suggest different things to different stakeholders. For example, from the provider administrators' perspective, service cost is a double-edged sword. Because when the cost of services is affordable to patients, they tend to have height frequencies, which in turn increases providers' revenue. This leads to providers having a competitive advantage, but simultaneously it reduces revenue and is likely to lower the quality of service. From this scenario, Fig.5, indicates that provider X delivers the most services, followed by provider Z, and then Y. The figure also shows that the Average service cost for providers X and Z is lower than Y, while they deliver more services. This suggests that maybe provider Y administrators need to reevaluate the costing and pricing of their services, and possibly identify cost-saving measures. Additionally, Fig.5 indicates that higher frequency of patients corresponds to higher average waiting times at the three providers while provider X in particular needs to pay close attention to its Average waiting time as it does not conform with the other two providers.

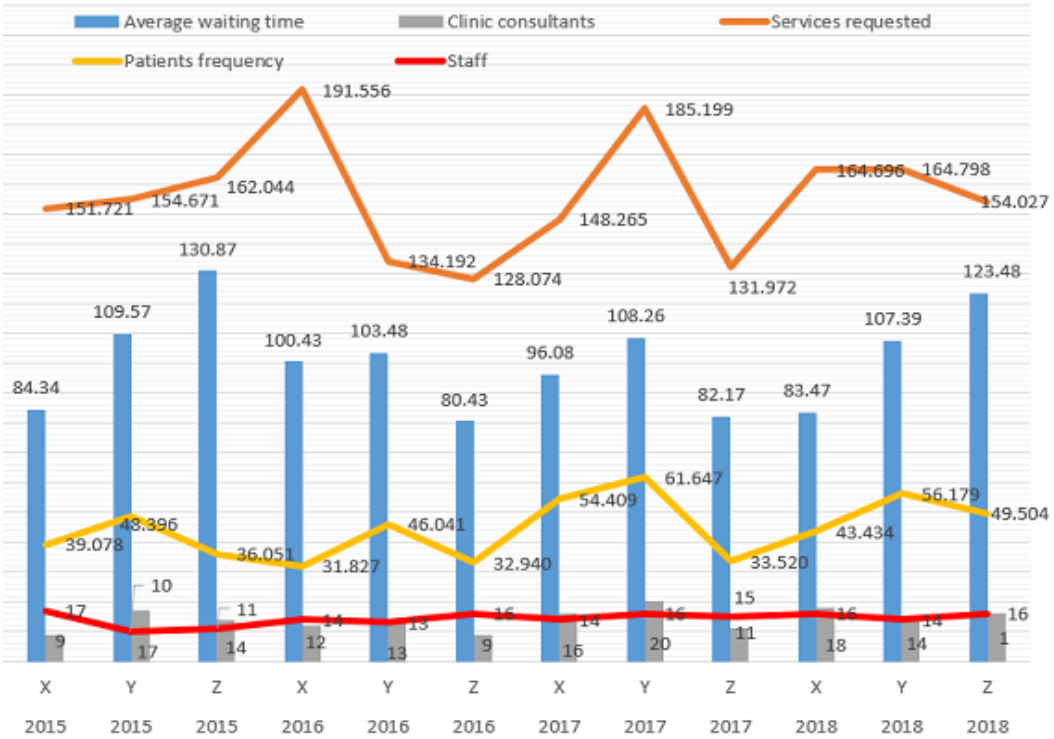


Figure 5-32 Time management dashboards

The third category of factors is the time management group. This refers to providers' time management including service delivery time and patients waiting time. Time management is critical as it directly impacts the providers' ultimate objective of patients' satisfaction. The units in Fig.5-32 are as follows: *Services* requested is the total number of medical services requested in thousands, and *Patient's frequency* is in thousands too, while *Average waiting time* is in minutes, and *Staff and Clinic* consultants. Clearly, the figure demonstrates the direct relation between the *Patient's frequency and both the Average waiting time* and *the services requested.* Additionally, the relation between *Average waiting time* and the *Staff* is an inverse relation. While there is a direct relation between *Clinic consultants and both Services requested and Patient's frequency.* All these results derived from Fig. 5-32 provide plenty of information and insight into minimizing patients waiting time. For example, decisions and further analysis of the levels of staff and consultants at the provider as they related to patient's frequency and services requested.

The preceding results have demonstrated the effectiveness of the BI model in analyzing, correlating and comparing different factors to expose their complex interrelationships and thus assist in improving healthcare services.

5.6. **Knowledge Discovery Data (KDD)**

The term Knowledge Discovery in Databases, or KDD for short, refers to the wide process to returns knowledge in data and emphasizes the "high-level" usage of particular data mining methods. It is of interest to researchers in machine learning, pattern recognition, databases, statistics, artificial intelligence, knowledge acquisition for expert systems, and data visualization. The main goal of the KDD process is to extract knowledge from healthcare data in the context of large databases for three type of case study bellow:

5.6.1. Time Management KDD

The impact of implementing DM predicting through Rabid Miner represent the healthcare information as knowledge to enhance the decision-making in this sector, so far in this section, we shall represent who to enhance the services waiting time through DM Rabid Miner tools at 25%, by using prediction through implementing (general linear models and deep learning and decision tree) that shown in Fig.5-33 bellow:

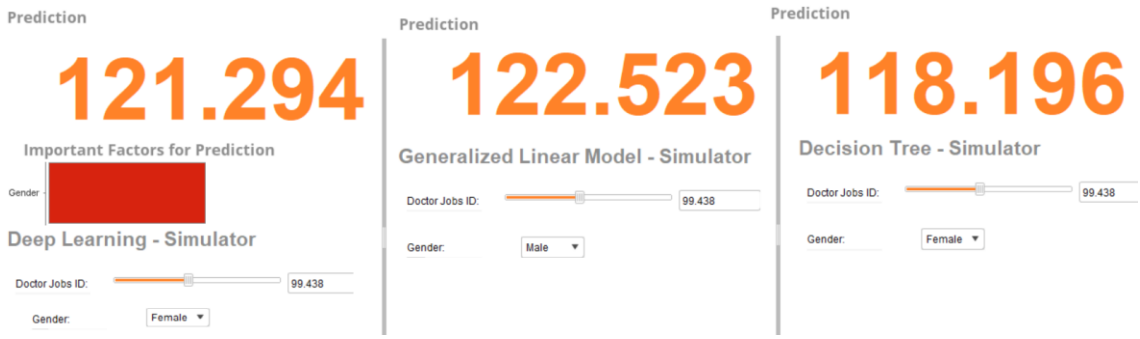


Figure 5- 33: Services Waiting Time Prediction

Figure 5-34 Illustrate to represent the knowledge of service time and waiting time for each physician job through DM Rabid Miner tools to enhance the decision-making in this sector, the Fig 5-34 also represent the statistical factor of the time management, that summarizing by time for each specialization in the hospital at the dashboard at Fig 5-35 bellow also.

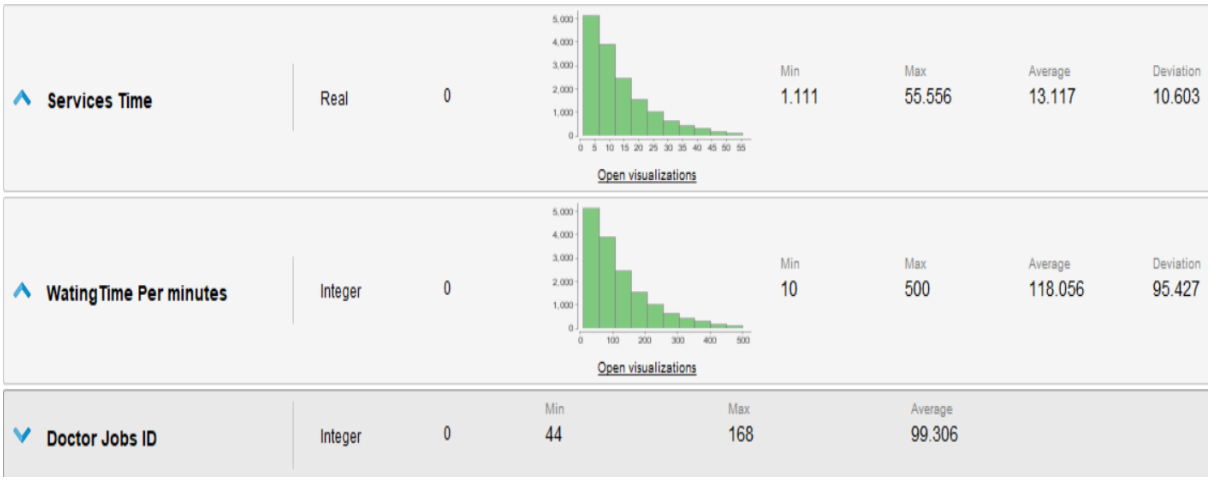


Figure 5-34: Specialization Time KDD

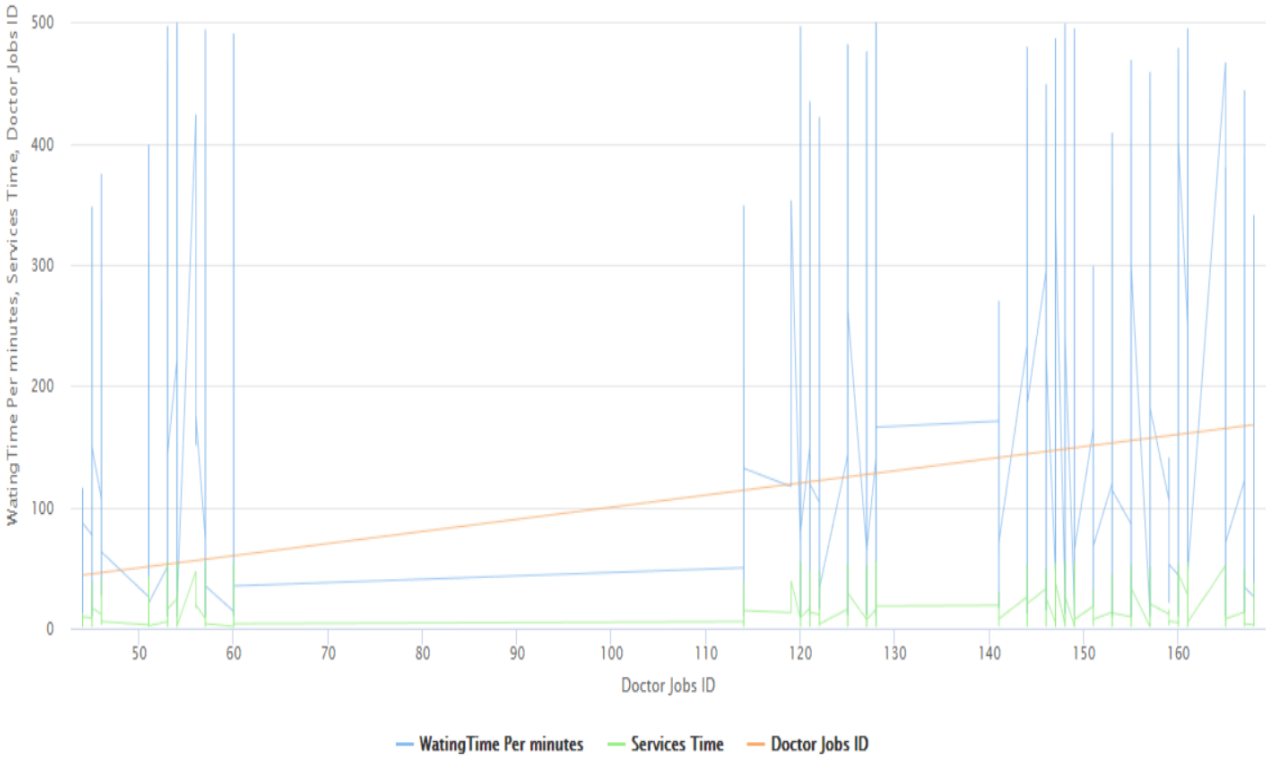


Figure 5-35: Specialization Dashboard Time KDD

Figure 5-35 It sheds light on the relationship of the average waiting time with the number of doctors within the concerned specialty, as it can show the average service time for each physician.

5.6.2. Providers Management KDD

The impact of implementing DM clustering and predicting through Rabid Miner using to transformed the information or row data to KDD, that process helping the

healthcare stakeholders or hospital decision-makers, for example the Fig.5-36 that reflect data row of Table 5-1 (Institutes Patient Frequency) to dashboard knowledge, to be understand for decision-maker to enhance their decision and healthcare sectors services by 11% based on statistical distribution that shown in Figs Fig.5-36 and Fig.5-37.

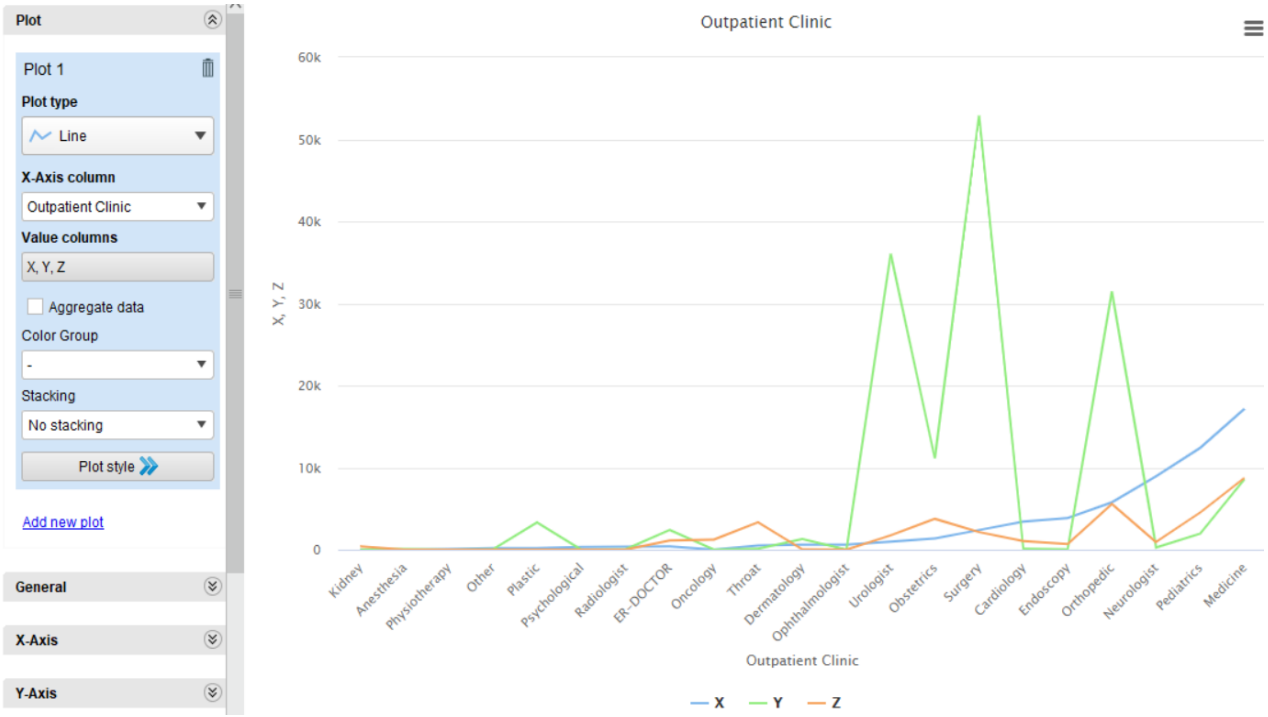


Figure 5-36: Institutes Patient Frequency KDD

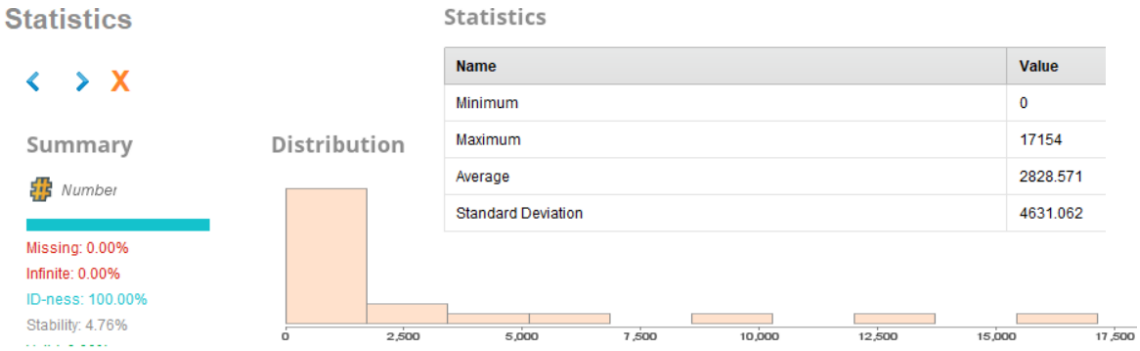


Figure 5-37: Institutes Patient Frequency KDD Distribution

5.6.3. Services Management KDD

The process of extracting knowledge from healthcare data through DM tools represent many knowledge's based on the data tow, in this section represent many dashboard knowledge (Fig 5-38 to 5-42) through Rabid Miner techniques. The Services and Gender Predictions and Services and Age KDD used Naïve Bayes approach as shown in figs Figure 5-38 and Figure 5-39.

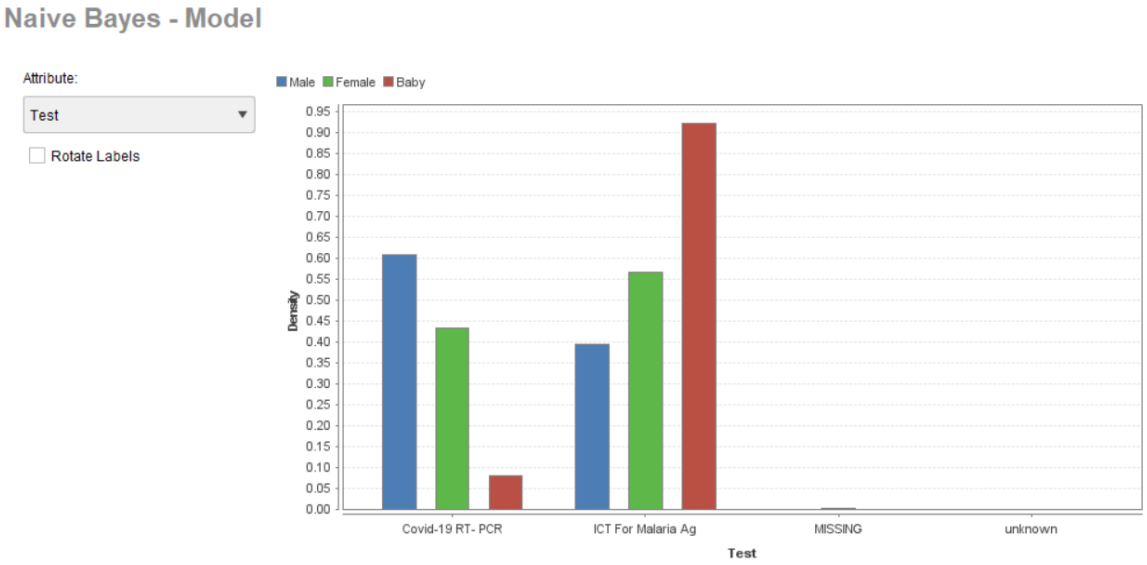


Figure 5-38: Services and Gender KDD

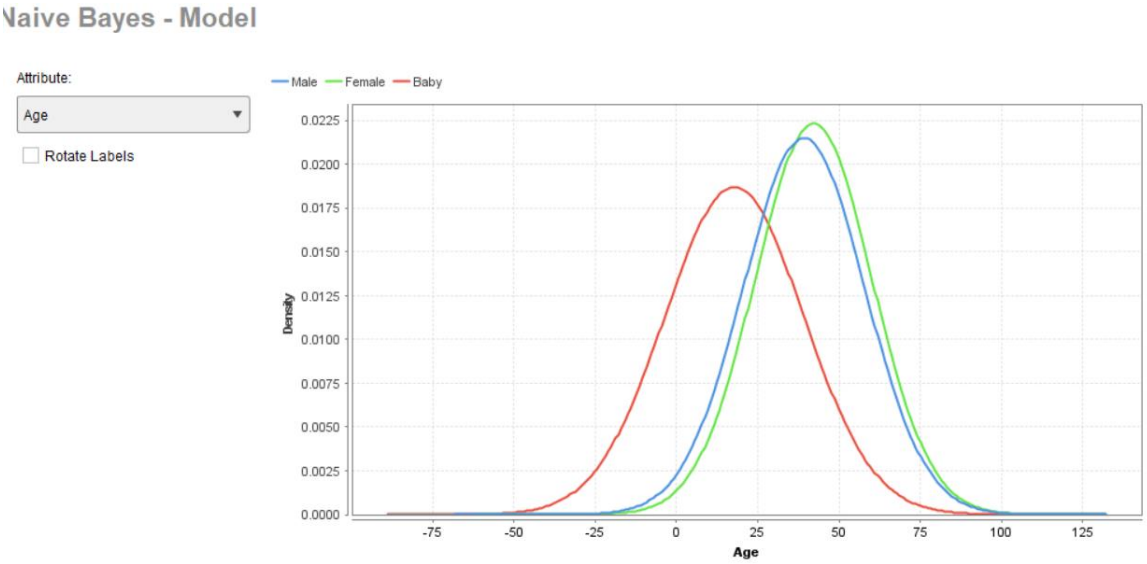


Figure 5-39: Services and Age KDD

Naive Bayes - Model

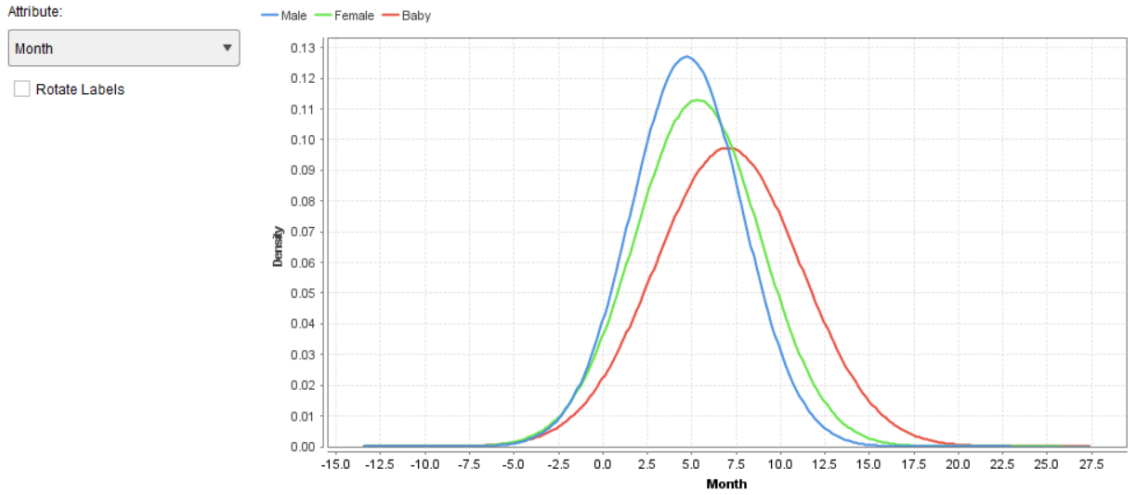


Figure 5-40: Services in Month KDD

Naive Bayes - Weights

Attribute	Weight
Test	0.449
Age	0.160
Year	0.139
Month	0.116

Figure 5-41: Services Weights KDD

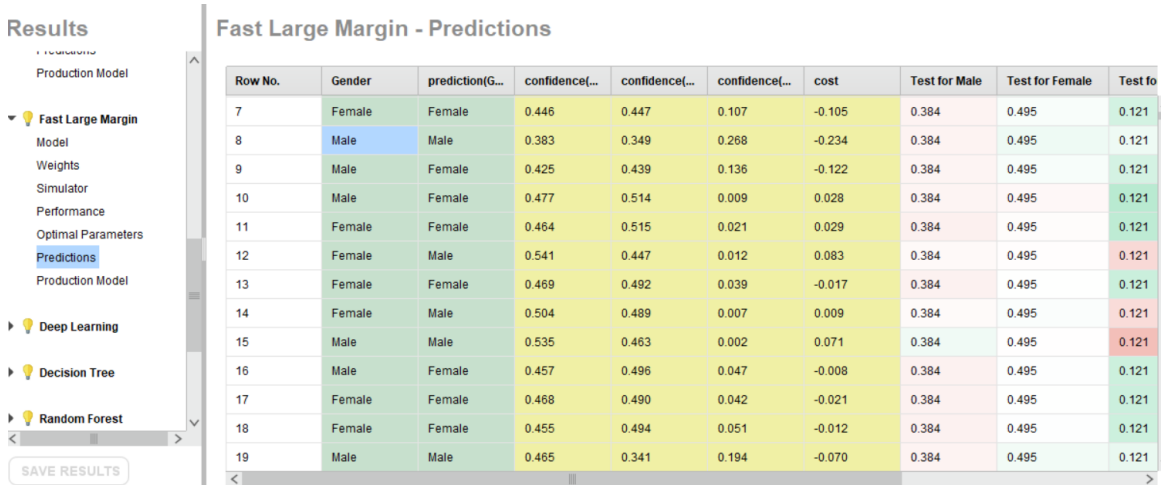
Results

- Comparison
  - Overview
- Naive Bayes
  - Model
  - Weights
  - Simulator
  - Performance
  - Predictions
  - Production Model
- Generalized Linear Model
  - Model
  - Weights
  - Simulator
  - Performance

Naive Bayes - Predictions

Gender	prediction(G...	confidence(Male)	confidence(Female)	confidence(Baby)	cost	Test	Age	Year
Female	Female	0.323	0.630	0.048	0.259	ICT For Malar...	39	2017
Female	Female	0.348	0.607	0.045	0.214	ICT For Malar...	48	2019
Male	Female	0.357	0.609	0.034	0.217	ICT For Malar...	56	2019
Female	Female	0.322	0.453	0.225	-0.094	ICT For Malar...	13	2019
Female	Female	0.301	0.598	0.101	0.195	ICT For Malar...	34	2017
Male	Female	0.289	0.416	0.295	-0.168	ICT For Malar...	11	2019
Male	Female	0.363	0.576	0.061	0.153	ICT For Malar...	32	2020
Male	Female	0.319	0.645	0.036	0.290	ICT For Malar...	69	2018
Female	Female	0.294	0.662	0.044	0.324	ICT For Malar...	61	2017
Female	Female	0.443	0.531	0.025	0.063	ICT For Malar...	46	2020
Female	Female	0.323	0.625	0.053	0.249	ICT For Malar...	50	2018
Female	Female	0.345	0.625	0.030	0.250	ICT For Malar...	64	2018
Male	Female	0.365	0.610	0.025	0.220	ICT For Malar...	76	2018

Figure 5-42: Services and Gender Predictions



Row No.	Gender	prediction(G...	confidence(...	confidence(...	confidence(...	cost	Test for Male	Test for Female	Test fo
7	Female	Female	0.446	0.447	0.107	-0.105	0.384	0.495	0.121
8	Male	Male	0.383	0.349	0.268	-0.234	0.384	0.495	0.121
9	Male	Female	0.425	0.439	0.136	-0.122	0.384	0.495	0.121
10	Male	Female	0.477	0.514	0.009	0.028	0.384	0.495	0.121
11	Female	Female	0.464	0.515	0.021	0.029	0.384	0.495	0.121
12	Female	Male	0.541	0.447	0.012	0.083	0.384	0.495	0.121
13	Female	Female	0.469	0.492	0.039	-0.017	0.384	0.495	0.121
14	Female	Male	0.504	0.489	0.007	0.009	0.384	0.495	0.121
15	Male	Male	0.535	0.463	0.002	0.071	0.384	0.495	0.121
16	Male	Female	0.457	0.496	0.047	-0.008	0.384	0.495	0.121
17	Female	Female	0.468	0.490	0.042	-0.021	0.384	0.495	0.121
18	Female	Female	0.455	0.494	0.051	-0.012	0.384	0.495	0.121
19	Male	Male	0.465	0.341	0.194	-0.070	0.384	0.495	0.121

Figure 5-43: Services and Gender KDD

5.1. **Summery**

The impact of implementing BI in Sudanese healthcare sectors and the contribution of BI Health Care Framework (Conceptual Model) represent the requirements needed for BI implementation in the Sudanese Healthcare industry either from type or format of data or classification (structural or un-structural) of information, after gathering data and restructured it and validate efficiency of the (SHCFM) the result indicates to say BI system easy to implement and use in the Sudanese healthcare industry, and also is necessary to making decisions in the Sudanese healthcare industry to achieve benefits of time managing or getting patient satisfaction and reduce the cost and expected future decisions based on the huge data that analysis by using Microsoft BI tools (Visual Studio 2012) with the component of analysis and integration and reporting service, that create dashboard result with it to help when we needed decisions based on summarizing report represent by the figure above.

The correlation result represents framework will allow access to information that we needed in less time to enhancing strategic decisions to achieves our goals to enhance healthcare sectors either from reducing the costs for patient treatment or operational expenses and quality of service and patient satisfaction, all this impact from summarizing information that extracting information from huge data is restructure on optimal manipulation of healthcare data to obtain it in a useful format to get that result explorer above either on Figure shape dashboard or summarized table.

After validating the (SHCFM) Framework Models and represent the result of the case study by the implementation of BI in the Sudanese healthcare sectors and that addressed in a chapter (6), here as shown above, how to stakeholders make an accurate decision based on information that mentions to it in this chapters, using elementary case study result, that divided into two categories First Single correlations inside the sub-use-cases, and Second multi correlations between the sub-use cases, each of them represent through it how improving informed decisions based on the implementation of BI technology in healthcare sectors.

In the first single correlation results describe how the stakeholders in the healthcare sectors especially the managerial and shareholders get the informed decision based on the relation between revenue and expenses on their institutes for all departments or units or selection department to evaluate their institutes from a financial perspective, and so what the Correlation between Revenue of each department and the manpower either in selection department or all institutes to determined what the relation between staff quantity and the Revenue and expenses, and so measure the sustainability of the institution by reading the revenue position compared with the expenses for any periods selected. and in figure (6-32) represent the correlation between revenue and expenses virus efficiency to get indicter between patient's frequency and its impact on revenues and expenses, and so that is means get indicators to the relationship between patient's satisfaction and a good reputation for institutes.

The healthcare institutes manager can also monitor which departments are most frequented by patients, that is, which are effective, profitable, and reputable and can be reliable from a competitive advantage in the healthcare market, and also it can represent how is the physician is backbones on that units or departments their institutes.

Also, we can evaluate healthcare institution from the administrative perspective, the framework model can also extract information of administrative nature from the perspective of the staff job satisfaction, considering the optimal investment in human resources, which is reflected in turn on the success of the institution. So we can review the number of staff in each departments or jobs and compare with turnover of staff in any institutes and the type of separation or job leaving, because

the type of leaving became as a performance indicator of the stability of the institution and the extent of job satisfaction.

So far the models can represent how many services coverage and provided by the any healthcare institutes, so the model is used to measure the services coverage in each healthcare institutes, that can be considered a competitive advantage for the institution.

The second multi correlations results represent the correlation between sub case study across the other case study to reflect several angles of the result , and measured from several indicators, to enhancing strategic decisions based on the dashboard information that get from implement BI in the Sudanese healthcare industry, by represent how does the services coverage within the institutes affected on patients frequency, and what is the frequency of the insurance patients compared with total patients frequency, and what is the patients insurance frequency percentage From general frequency, To reflect some indicators to represent the institution position in the marketing of health care, and what is its weakness and competitive strength? , in this case the beneficiaries from this KPI dashboard is the institutes manager and shareholders to put the strategic plan.

But from the other side the patients they can benefit from dashboard that represent the several intersections in indicator from many perspective , Services coverage to know availability of services in any healthcare institutes , and the total services cost get indictor to patients with average service cost what is the institutes services is affordable to them , when he measured by cost , and so we can measured with more than two aspect like average service time with average waiting time, frequency of patients, to determined , what is lower cost and no waiting to get its services . this is from patients perspective, but the institutes manager and its shareholders also need to making decisions based on that indictors but is became from deferent perspective , that became more efficiency when adding to them revenue and expenses percent with number of staff indictor, to represent influence of services cost and human resources to reduce the expenses and increase the revenue , and so influence of manpower on the waiting time and the services time , all of this to achieve the patients satisfaction and increase the revenue and decrease the expenses, and get the institutes going concern .

The third multilayer correlation results serviced all healthcare stakeholders, each of them according to its access privilege, and the type of decision to be makes based on information that represent by using implementation BI in healthcare sectors, like the polygon of the six-party information, can be seen from more than one angle of vision, and each of angle reflects more than a different vision from the other angle, because it affects from more than a drop-down angle of information. After all, the SHCFM provides healthcare stakeholders multi angle of information dashboard to improve informed decisions on the healthcare sectors. for example relation between services coverage and number of staff , beside influence of staff qualification, and so the influence of by patients frequency for them , or both services coverage and average waiting time it have related with frequency, taking into account the main perspective is the patient satisfaction aspect is majored by patient frequency , or whether they are influenced unique competitive advantage, and also represent the relation between patients satisfaction from reduce service cost perspectives and institutes Revenue across patients frequency, beside the reflected of reduce the services cost to get patients satisfaction and high patient frequency, and also get the angle of healthcare service provider from serve community perspective, by providing affordable services to its patients, and availability of services aspect, on the anther side we can see relation between insurance company contract and frequency of patients and also to what extents is reflected insurance on the Revenue and expenses. all of them represent the implementation of BI in Sudanese health care institutes serve many actors related with this sectors either patients that represent the corner stone of this cycle, or stakeholders or the community or all governmental level via the Federal Ministry of Health, all of it needs comprehensive report to make good decision for strategic planning, coordination and harmonization of all health actors'. enhance healthcare sectors base on the improving informed decisions in the healthcare domain based on BI.

CHAPTER VI

CHAPTER VI

Conclusion and Recommendation

6.1. Conclusion

The motivating factor for the proposed research work in to improving informed decisions in the healthcare domain based on the implementation of BI and DSS in the healthcare sectors ,which contributes to the patient's interest in the first place by making accurate decision to determine the therapeutic destination from many perspective and factors based on its situation like service coverage, cost, time ,quality of services, and its satisfaction services delivery, and hence the interest of the healthcare institutes and its executive management to explorer strengths and weaknesses point, raise the value of the competitive advantage, and making the appropriate and timely decisions to enhance the development of health care sector and its institutes by increase revenue, reduce expenses, obtaining job satisfaction for employees , obtain patient satisfaction and reputation, health data sharing , assisting the government to upgrading the health sectors, and also the unique nature of the healthcare data and its analysis requirements taking into account benefits another beneficiaries that describe in the Table 5-3 beneficiaries from BI framework. Healthcare industry is now realizing the need of a proper BI Tools infrastructure and moving towards it by that notes mention above in the Table 5-3.

There are many BI tools available to implement in health sectors industry. But they also couldn’t retain the unique nature of healthcare sectors. If we look at the cost of these tools, they are not less than a few thousand USDs, which makes it unaffordable by many clinics and hospital either private or governmental organizations, as the return of investment is too less. This leads us to the question of the beneficiaries of this application other than the patient, we find that the State involved in the development of health care and quality in addition to the institutions operating in this sector, so are in the currency of application in addition to the suppliers of drugs and medical consumables, all of them are to contribute to the process of application materially and morally. Table 5-3 shows a Beneficiaries from BI Framework Models. The BI System demands a unique solution. A good decision support system

can not only improve the quality of care but also reduce the cost and reduce waiting time and leads to raise the spirit of competition between healthcare institutes, that lead to the provision of medical services with quality and price affordable to the patient.

All countries are looking for the best approach to manage population health. This has become a repeatedly discussed subject and because cost and quality of service become alarming to the various healthcare organizations, this besides the many factors that must be taken into account, like security of patient information, and laws of the countries and the prevailing customs and traditions. Therefore, the healthcare system must keep pace with ongoing changes in the sector as well as technology advances, to improve the approach to healthcare delivery.

Float on the surface many challenges in responding to this change is how to coordinate the requirements of the patient healthcare. If the healthcare system can become efficiently coordinated healthcare between patients, providers and others, it will contribute to the better management of the alarming challenges facing the entire communities' health.

Healthcare providers need a robust BI foundation to integrate data, analyze, and clean useful information for medical data, or financial and operational data. to improve informed decisions based on accurate data, extracted and analyzed in real-time by the BI tools and DSS that accomplish a variety of functionality to achieve good quality in the healthcare sector and reduce cost, limit medical errors, and highlight future expectations in the healthcare sector, including emergency, surgical, and pharmacy analytics, as well as insight into physician quality, improved performance, and patient satisfaction, and patient outcomes. Furthermore, the BI tools can also help achieve better understanding of ACO activities.

The main contribution of the envisaged thesis is to show how the capabilities of BI, in combination, use health data and information to create knowledge that serves as input for decision making and forecasting in the healthcare industry, by designing a framework to structure a Business Intelligence solution to achieve future strategic decisions to promote the healthcare sector and contribute to the patients safety, and reduce pandemics in line with the world health policies, and government policies.

How these capabilities are realized in different contexts is part of a valid model framework that gets the effective result from this analysis. Based on this argument, the research investigates and relies on existing literature and Best Practice examples to show how BI capabilities support organizational capabilities in the healthcare sector and provides examples of their effectiveness to improve the quality of care and reduce cost. The research questions explained require an understanding of the context of implementing BI systems for improving informed decisions in the healthcare sector.

6.2. Contribution

Create a Framework model that helps stakeholders in the healthcare sector to make decision-based on historical and timely data and transfer it to information to be able readable and understandable and easy for any stakeholders according to the required of information, within its permission and the access limits.

The Framework Model has the ability to extract patient data from other healthcare institutions with a contribution on patient's data sharing, that reduce the medical errors and, reduce the time lost to know the patient's demographic data, and family history, and also its diseases history especially if the patients in the case of loss of consciousness, which helps in the process of rapid diagnosis that may be the reason for saving his life.

Produce a central database of health in Sudan that can be saved on DW or Data Clouding. This helps to speed up the process of accessing required data and reports that may contribute to the development of the health sector in Sudan, in addition to providing data to researchers, taking into account the confidentiality of financial institutions and patient data, which generates a high degree of reliability and privacy.

Produce dashboard for each stakeholder to make the right decision according to their current situation and information, through which managers of medical institutions can monitor and manage the institution easily without suffering from the jam of paper reports, which may be inaccurate in many cases, and on the other side enables the prediction of the future, whether at the level of control of seasonal diseases and chronic or accidental infection of areas for the Ministry of Health And the World

Health Organization. As for suppliers of medicines and medical consumables, they can make forecasting to its purchasing process from any consumable or drugs, based on the information of disease and operations that doing in the healthcare institutes. As well as medical insurance companies can follow the files of patients, and work to reduce the cost of treatment for them, working to combat diseases in coordination with ministries and international organizations and voluntary, which benefits the community as a whole.

Raising the spirit of competition between medical institutions, which is reflected positively on the healthcare field, by the contributed quality of service provided, and medical service coverage, and reduce the medical services, and reduce the average services waiting and make them accessible for the patients to compare between the services provided by each institution and its price, and what is covered by all the units and therapeutic departments, which make them the forefront of competitive, so that the patient finds everything within the needs of the one health institution, affordable price, in addition to health care that satisfies patients, even in What is related to the follow-up and prompt response and care of the staff working in the medical sector, whether doctors, nurses or administrators.

Adding Knowledge values on the BI area especially in the healthcare sectors. Especially in the Sudan healthcare sectors, which creates a rich and versatile research area because it is based on DW, that contains many structured Database and is in the same format, although it is the summary of all health institutions in Sudan.

adding the value of privacy and information security readability, the central database or DW helps to keep the information confidential and make it circulation within the privilege of access only, so that the integration of data between the health institutions among them in terms of patients and their illness, which makes them do not deal with files that may be lost or seen by the intruders, which is in favor of patients to support their privacy and confidentiality of their data.

Jobs satisfaction and going concerned for any institutes either industrials or healthcare institutes, one of the success factors for each institution, But in health care institutions become more important because they have a direct impact on the

form of service provided in the institution, which reflected positively or negatively on the satisfaction of patients, so the success of any institution depends on the satisfaction of the workforce of the institution, On its progress and profitability, or its loss and low reputation for service.

Represent financial position of healthcare institutes that lead to being is supported by donors and funded by its community service in the field of health care, with a strong and transparent financial position through which it can obtain any bank financing or loans to assist in the vertical and horizontal expansion in the development of the health care sector because of its good reputation and financial position. Not swaying.

6.3. Future work

The researcher recommending in the future linking the model of public health institutions, as well as quasi-governmental institutions so that each test model circuit is completed with all the provision of health services in the fields of Sudan to by easy to extract all of the information of any patients. So that the patient's data can be linked with the national registry, as well as with the judicial and academic records and licenses, whether to obtain a driver's license or possession of a firearm, so that his / her health may be revoked, which may prevent him from obtaining a license to engage in a particular activity or possess a license to use a gun for example.

The Framework Models is must be for evaluate the many factors in depth like patient’s satisfaction, and job satisfaction.

The proposed model is applied in the work of suppliers of pharmaceuticals and medical consumables, to be part of decision-makers as it provides the model information. To check the prices of their purchase of medicines and medical consumables, so that they can control their pricing and not be a part of the increase in the cost of medical services, which are reflected in turn to the patients, as well as control the validity and quality of medicines and consumables and their suitability with the nature of Sudan and its diseases, Through the model, for example, to provide data to the Supreme Council for Pharmacy and Toxins, which is the regulatory body in this regard.

The Framework Models is must be linked with e-government and civil and criminal record data to be a complete circle of information, for any populations, to assist the state of many stakeholders with many decision aspects. As the model reflects the medical side of the population, as well as the cases of deaths that occur and their causes, which can often be avoided, by the proper planning provided by us, use the mode of implementation of BI, as well as find the birth record and type of its gender so that the government planning to build on this data provided by the model through DW.

Consider the DW Framework in terms of the privacy of data and confidentiality of information more accurately and comprehensively, Furthermore, the idea of adopting cloud storage, from the heart of the work of the government that is the main beneficiary of the idea of application, which helps in the speed of access to the information, so it was necessary to recommend in the future in-depth in the concepts of privacy and data security, to look at the DW Frame models of privacy more precisely and more detailed than we described in this research.

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