The Impact of Enhancing Outpatient Clinic Management Software in Reducing Waiting Time in Saudi Hospitals

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The Impact of Enhancing Outpatient Clinic Management Software in Reducing Waiting Time in Saudi Hospitals

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ABSTRACT

Healthcare services are considered humanitarian in the first place as they deal with persons inflected by diseases that could affect their lives and lifestyles. The developed countries have realized the significance of such services and consequently have built hospitals and allocated large budgets and huge resources for this purpose. Saudi Arabia has been among the countries giving keen attention to this issue. As an integral part of the healthcare services, the outpatient clinics play crucial roles in providing specialized healthcare services based on contemporary information systems. However, one important drawback in using such systems is the long waiting time of patients in the clinics, which in turn affects the level of patients’ satisfaction as well as the quality of the services provided.

The current study has focused on the outpatient clinics in Saudi Arabia and the time it takes the patient to end her/his visit to the clinic. Moreover, this study has addressed missing requirements of the current outpatient clinics management software and the reasons behind long patient’s waiting time. The study has selected a large public hospital provided with healthcare electronic system in its outpatient clinics. Data collection has been based on the following methods: survey to measure the level of patient’s satisfaction, interview with the outpatient clinic team including the medical doctor, the nurse. The appointment queue data for data analysis extracted from outpatient clinics systems.

The research has mainly concentrated on investigating the current outpatient clinics management software by studying its architecture and deeply looking for issues that affect the waiting time. Defects have been figured out in the application of the Healthcare electronic software systems related to both Requirement and Design Phases. This, in turn, has negatively affected the patients waiting time. Many problems that cause long patients’ waiting time have been identified by this research,
including overbooking, physician’s late arrival, patient’s early arrival and patients’ distribution list.

Five solutions have been developed and substantiated analytically or by simulation to reduce patients’ waiting time and eventually raise the level of satisfaction among patients.

The study has shown improvement in reducing waiting time in outpatient clinics through solving the overbooking problem by specifying time for each overbooked appointment to obtain the maximum benefits. Queue ticket number issue was solved by generating the ticket number before clinic starting time to minimize the effect of no-show appointments. Late doctor reporting time issue was solved by implementing time attendance system which reduces the clinic service time by up to 20%. However, early coming patient solution reduces 53.3% of total vital time, 20% of the clinic total time and overall 30.3% of the total waiting time. Finally, patient distribution list was missing in the requirement phase; it has been solved by adding new functionality that helps doctors to distribute their patients to several rooms. This solution decreases the service time by 54.2%. 
ملخص البحث

تأخذ الخدمات الطبية بعدا إنسانيا لأنها تتعامل مع مريض يعاني من مرض يؤثر في بعض الأحيان على مسار حياته وأسلوب عياشه، ولما كانت الدول الكبرى تؤمن بأهمية هذا الحق العام بنت المستشفيات وخصصت لها ميزانيات ضخمة وإمكانيات عظيمة. وكانت المملكة العربية السعودية إحدى هذه الدول التي وابدت التطور الظاهري وانهائه اهتماما كبيرا كجزء أساسي من الرعاية الطبية وتعتبر العيادات الخارجية في المستشفيات من الأدوات الخدمية الهامة التي تقدم خدمات صحية مترخصصة للمرضى بالإعتماد على الأنظمة المعلوماتية الحديثة. ولكن الحلقة المفقودة في تقديم الرعاية هي طول مدة انتظار المريض داخل العيادة ومدى تأثير هذا الانتظار على مستوى الرضا العام عن جودة تقديم الخدمة حيث تركزت الدراسة على العيادات الخارجية في المملكة العربية السعودية من خلال دراسة الوقت الزمني الذي تستغرقه العيادات لإتمام خدمة المريض خلال زيارته للعيادات الخارجية. وكيف تسامى هذه الاضربات في تدشين الصعوبات التي أثرت بشكل سلبي مباشر على وقت انتظار المريض، كما ساهمت بشكل غير مباشر في رفع مستوى عدم الرضا عن الخدمة لدى المرضى. وقد اختير مستشفى حكومي كبير لديه نظام إلكتروني صحي.

تم جمع البيانات من خلال استبان لقياس مدى رضى المرضى ومتابعة طاقم العيادات الخارجية مثل الطبيب والممرض وموظف الإستقبال، وكذلك تحليل البيانات التي تم استخراجها من أنظمة العيادات الخارجية المختلفة. وتتميز في هذا البحث على دوره حياة مشروع نظام العيادات الخارجية ودراسة الهيكل البنائي للأنظمة المرتبطة بها. تحدد الفجوات التي أثرت بشكل مباشر على معدل الانتظار المريض. حيث وجدت فجوات في التطبيق البنائي للأنظمة في المرحلة: مرحلة جمع المتطلبات ومرحلة التصميم، مما أثر بشكل سلبي على معدل الانتظار المريض. ومن أبرز الفجوات التي وجدتها الدراسة التي ساهمت بشكل كبير في زيادة معدل الانتظار المريض مشكلة المواعيد الإضافية، وتأثر الطبيب في بدء العمل في العادة، والإيجاب المبكر للمرضى كان له كلاً أن أثر على معدل الانتظار المريض للفحص المبكر.

وقد تم تطوير حلول للصعوبات التي وجدت وإثبات فعاليتها من خلال المحاكي الذي يقوم بتوقير الحلول المناسبة بشكل علمي وإثبات فعاليتها هذه الحلول في تقليل معدل الانتظار الذي يؤدي بدوره لرفع مستوى الرضا لدى المرضى. وقد تم استخدام المحاكي في إثبات فعاليتها للحلول المفترضة.

أظهرت الدراسة تطورا واضحا في تقليل نسبة الانتظار المرضى من خلال حل مشكلة المواعيد الإضافي وإضافة عامل الوقت لها لامكاني قياسه بشكل دقيق. كما أن تغيير ترتيب الصعوب حسب المودة المعطى هدفه تقليل الانتظار المرضى من خلال ربطها بالترتيب المنطيقي للانتظار والاستفادة القصوى من المواعيد غير المستخدمة أنتصب بالنسبة لمشكلة تأخر الطبيب على العيادة فقد تم حلها عن طريق ربط نظام الصعوب بنظام الحضور مما ساهم في تقليل نسبة خدمات العيادات إلى

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20% حضور المرضى مبكرا أيضا ساهم في زيادة وقت الانتظار لذا كان لابد من ايجاد حل ساهم في تقليل 53.3% من وقت قياس الاشارات الحيوية 20% من وقت العيادة و 30% من وقت الانتظار الكلي. وكانت أبرز المشاكل التي نتجت عن ضعف في جمع المتطلبات كان توزيع المرضى على أكثر من عيادة الكترونيا حيث ساهم الحل في تقليل خدمة العيادات بنسبة تصل الى 54.2%.
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<tr>
<td>AST</td>
<td>Appointment Service Time</td>
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<tr>
<td>AV</td>
<td>Arrival Time</td>
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<td>AWT</td>
<td>Appointment waiting time</td>
</tr>
<tr>
<td>BNHS</td>
<td>British National Health Service</td>
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<tr>
<td>CIS</td>
<td>Clinical Information System</td>
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<tr>
<td>CPOE</td>
<td>Computed Physician Order Entry</td>
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<tr>
<td>CST</td>
<td>Clinic's Service Time</td>
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<tr>
<td>CWT</td>
<td>Clinic Waiting Time</td>
</tr>
<tr>
<td>DICOM</td>
<td>Digital Imaging and Communications in Medicine</td>
</tr>
<tr>
<td>DT</td>
<td>Discharge Time</td>
</tr>
<tr>
<td>ED</td>
<td>Emergency Department</td>
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<tr>
<td>ENT</td>
<td>Ears, Nose, and Throat</td>
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<td>ERP</td>
<td>Enterprise Resource Planning</td>
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<td>ESL</td>
<td>Effective Satisfaction Level</td>
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<td>FAFS</td>
<td>First Appointment, First Served</td>
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<tr>
<td>FIFS</td>
<td>First In First Served</td>
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<tr>
<td>HCI</td>
<td>Human-computer interaction</td>
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<tr>
<td>HER</td>
<td>Electronic Health Record</td>
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<tr>
<td>HIMSS</td>
<td>Healthcare Information Management System Society</td>
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<td>HIS</td>
<td>Health Information System</td>
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<td>HL7</td>
<td>Health Level 7</td>
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<tr>
<td>IE</td>
<td>Integration Engine</td>
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<td>IHE</td>
<td>Integrated Health Exchange</td>
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<td>LIFS</td>
<td>Last In, First Served</td>
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<td>KSA</td>
<td>Kingdom of Saudi Arabia</td>
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<td>LIS</td>
<td>Laboratory Information System</td>
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<td>MOH</td>
<td>Ministry Of Health</td>
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<td>Full Form</td>
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<tr>
<td>MRN</td>
<td>Medical Record Number</td>
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<td>OMS</td>
<td>Outpatient Management Software</td>
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<tr>
<td>PACS</td>
<td>Picture Archiving and Communications System</td>
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<tr>
<td>RIS</td>
<td>Radiology Information System</td>
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<tr>
<td>RSNA</td>
<td>Radiology Society for North America</td>
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<tr>
<td>SDLC</td>
<td>Software Development life Cycle</td>
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<td>SOA</td>
<td>Service-Oriented Approach</td>
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<td>VTS</td>
<td>Vital Service Time</td>
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<tr>
<td>VWT</td>
<td>Vital Signs Waiting Time</td>
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<td>WFMS</td>
<td>Workflow Management System</td>
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CHAPTER ONE: INTRODUCTION
The Kingdom of Saudi Arabia (KSA) is one of the biggest countries in the Middle East; it’s population is estimated 29.898 million according to the Population Information Network, the life expectancy gained 9.4 years from the period 1980-1985 to the period 2005-2010, going up from 64.9 years to 74.3 years. It is expected to reach 81.8 years for the period 2045-2050 [1]. This life expectancy increased because of the improvement of health care in KSA during the past 60 years since the establishment of the Ministry of Health (MOH) in 1950. [2]

KSA provides free healthcare services to the Saudi citizens according to MOH policy. This policy is committed to provide a health service to every Saudi. The objective of the MOH is “to provide non-profit medical care for all Saudi citizens in public healthcare facilities” [3]. MOH has three health care levels, primary health care, secondary healthcare, and tertiary health care. Figure 1.1 shows a total of 2337 health care facilities of which 2037 represent primary care centers distributed all over the kingdom, 244 secondary care hospitals in all cities, and 56 tertiary hospitals in major cities.

Figure 1.1 also shows the MOH healthcare levels. The healthcare centers or hospitals provide an outpatient clinic service to all Saudi citizens; the patients are treated in these centers or hospitals depending on the complexity of their health situation. If the condition is stable, the patient should go to primary care. If not, s/he will be treated either in the secondary or tertiary care. Most of Saudi citizens prefer to follow up their health check in primary care centers because the number of primary care centers is huge and this will reduce their waiting time.
The secondary and tertiary healthcare hospitals have two major services, inpatients and outpatients. The outpatients are usually managed by scheduling software that helps organize the patient’s time and control hospital capabilities. These capabilities include human resources, physical locations (such as clinic rooms or procedure rooms), medical devices, medicines, etc.

1.1 Motivation

The prime motivation for this study is to integrate the health care management system within the outpatient clinical setting of Saudi Arabia to assess its effects on improving the patients’ flow and also address the potential challenges facing outpatient clinics. Considering the past observations, there was greater motivation for the researcher and, as a matter of fact a strong need to conduct a research to upgrade the outpatient management system.

Most of the studies have agreed that the satisfaction level of patients in outpatient services are related to waiting time beside the quality of medical service [5]. The patient is the main core customer for the healthcare sector. Since the patients are sick and their health condition is not stable, extra waiting time for them will be humanely unfair. We know that the Saudi government through MOH aims to provide the best level of health
care in good quality by allocating a large budget every year. Government spending on the (MOH) increased from 2.8% of gross domestic production in 1970 [6] to 6% in 2005 and 6.2% in 2009 [7]. The total spending on health care during 2009 was 5% [8]. And according to Arab News, the MOH budget is 54.35 billion Saudi Riyal in 2013 allocations, 15.45 percent more than that of 2011[9].

Figure 1.2 shows Health Information System (HIS) Architecture which is a complex portrait of how the different software modules communicate with each other using centralized services and bus integration layer called “middleware” or sometimes called Integration Engine (IE) [10]. In Figure 1.2, the outpatient software is one of the integrated software that communicates with each other using a service bus. Therefore, making changes or development in any software is very costly, especially because most of the health information systems are based on studies and knowledge for many years. In addition, changing request takes a very long process because it is linked to other software which should be studied carefully for the impact of change before introducing any development. [10]

![Figure 1-2 Conceptual Architecture of a Health Information System [10]](image-url)
Saudi Arabia’s healthcare system has greatly improved within the last few decades as the government has been giving high priority to the quality and quantity of the health services, with additional population of visitors each year, which certainly increases the number of patients in the outpatient clinics as compared to the inpatient clinics [10].

In this study the focus is on the customer feedback "the patient" in outpatient service by studying the outpatient management software from software engineering point of view to control the waiting time of patient in order to increase the level of satisfaction and then improve the quality of healthcare services. Another point is how software engineering will help in reducing the healthcare organization budget and increase the clinic utilization.

1.2 Problem Definition

Mohammed, 48 years Saudi male, has a cardiac disease. He visits the hospital every three months to check his heart functions. He arrives to the hospital at 8:00 am, while his appointment is at 8:30 am, the nurse calls him for vital signs. After that, he returns to the patients waiting area. Mohammed knows that his appointment will take time, so he takes permission from his work for all morning time. The doctor comes at 9:15 am, so Mohammed waits for 45 minutes to see his doctor. Mohammed believes that all government sectors are the same; they provide a service without focusing on patient expectation or even satisfaction.

Patient flow is the most critical factor within the outpatient clinical settings, as it directly affects the patients’ health and their satisfaction level. Outpatient clinics and their staff members are involved in a variety of activities, where information management, accurate use of data, appropriate allocation of resources, and timely execution of processes are all necessary to maintain the patient flow within the clinic [11].
Software engineering has offered a wide range of technological assistance to the medical and healthcare field, while healthcare management systems have facilitated many domains including outpatient clinics in many countries to enhance the patient flow; therefore, this study analyzes the impact of improving software within Saudi Arabian outpatient clinics by demonstrating the actual delay time for outpatients. In outpatient services, the patient flow determines the advanced movement of people, equipment, and information through a series of processes. In healthcare, the term indicates flow of patients between staff, departments, and organizations along the path of care [12].

1.3 Research Scope

The scope of the study is confined to many aspects: first of all the research literature is based on the studies and journals from various countries, but the data collected for the analysis is collected from Saudi Arabia. Only outpatient clinics in Saudi Arabia have been considered for analyzing the impact of Software engineering system in improving waiting time. There are various software engineering technologies and methodologies used in the outpatient clinical settings to improve the patient flow; however, this study focuses on the outpatient clinic management software requirement phase which is an important phase in the Software Development Life Cycle (SDLC).

1.4 Research Question : Aim and Objective

The primary research questions are:

- How enhancing the Outpatient Management Software (OMS) will improve the waiting time in Saudi Arabia outpatient clinics?
- What are the missed requirements that need to be considered to improve the outpatient system?
The aim of this research is to analyze the SLDC of outpatient clinic management software in Saudi Arabia to improve the patient flow. Also, to demonstrate the impact of outpatient management software on reducing waiting time for patients within outpatient clinics of Saudi Arabia. Moreover, it analyzes the effectiveness of outpatient healthcare management software within outpatient clinics to facilitate the clinical staff in various clinical processes to reduce the patients’ waiting time.

The objectives of this research is to study the impact of improving the outpatient management software on patient flow and this requires to:

a. Study the impact of requirement engineering and software design processes.

b. Study current challenges facing improvements of patient flow and evaluate their impacts.

c. Offer proposals that ensure patients will receive their service care at the right time and the right place.

1.5 Research Methodology

The research approach used in this study is based on primary information gathering and data collection using both qualitative and quantitative approaches. Both methods have been used to study the outpatient management software requirements. In Figure 1.3 illustrates how this study investigates and solves the problems affecting waiting time through the following phases:
1. Gathering and Analysis requirements of the current system.
2. The design of the proposed solution.
3. Implementation using simulation.
4. Testing results from the simulation.
5. Maintenance is not applied here since it is considered a post-implementation solution.

As a start, firsthand information was collected from selected participants to analyze the information using both qualitative and quantitative research techniques.

- The data has been collected from KSA-Hospitals' Outpatient Management Software (OMS) using oracle database and for the referral software using Microsoft database. The consultant and salary information have been taken from Enterprise Resource Planning (ERP) using Oracle database.
- A basic tool in process analysis called Fishbone cause-and-effect method has been chosen for analyzing the factors that have a direct impact on patient flow from different perspectives. There are six factors that have a direct impact on patient flow management, measurement, people, machine or technology, environment, and methods or processes. The research will go over these factors and explain the causes in brief.
There are two instruments used in this study analyzing the current (OMS) and its impact on the patient flow in outpatient clinics.

- The interviews were conducted with the staff members, managers, and software users to determine the information collected within the planning, design, and implementing phases.

- A survey questionnaire was designed to examine the level of satisfaction from the patient point of view. However, the interviews focused on the requirement phase in (OMS).

This study focuses on the missing requirement problems and poor software design problems as will be explained in the next chapter. The proposed model will be implemented by using simulation.

The survey is given to figure out the level of patient's satisfaction with the current service in the outpatient clinics. The interviews for requirement phase constitute a collection of information based on the knowledge, experience, and beliefs of the participants about the current software and patient flow.

The design phase constitutes a collection of information based on the participants’ perception and experience about the ease, user friendliness, convenience, accuracy, and time efficiency of the software component. The survey data serve to identify the problem from a patient point of view and the analyses of current data to come up with proper description of current problems. Simulation is used to verify the improvement of patient waiting time before and after implementing the proposed solution.

The outpatient workflow includes the sequence of actions as listed in Figure 1.3 patient arrival, nursing assessment, nurse documentation, examination, and medical order that includes laboratory service, medical imaging, pharmacy service, special procedure or treatment. Then discharge after giving the patient the next appointment.
Figure 1-3: outpatient general workflow in Saudi Arabia

In KSA-Hospital, two types of visits can be identified: scheduled and non-scheduled. The scheduled visits, mostly made for clinical departments for internal and external procedure, are mostly reserved according to timely appointments. For example, before the patient sees the consultant, s/he is given an appointment slip that contains consultant's name, clinic's name, and time. However, if the patient has an order to a laboratory procedure, s/he will be served according to her/his arrival time "non-scheduled". There is no implemented software schedule for most of internal (medical procedures inside the clinic) and external procedures (medical procedures completed by another department).

Due to the time and limitation of resources, the scope of this research is concerned with the workflow inside the clinic, starting from patient arrival and then moving on to vital assessment, clinical or physical examination and then discharge. All the internal procedures like vaccination and pulmonary tests and external ones like pharmacy and laboratory services are out of scope of this research.
1.6 Contributions

The primary contribution of this study is to enhance the outpatient management software by reducing the waiting time without compromising the quality of service. The study’s key contribution focuses on the field of software engineering and healthcare management researches, with special attention to outpatient clinics in Saudi Arabia.

The following contributions have achieved by this study:
1- Conducting problem root cause analysis or fishbone to identify problems related to patient flow in Saudi Arabia.
2- Study the software requirements phase and identify the main problems that affect patient waiting time.
3- Propose five solutions to improve patient waiting time.
4- Provide recommendations to hospitals’ management on how to reduce patient waiting time and improve the quality of health care services.

Five solutions have been proposed in this study and then developed and validated analytically or by simulation to reduce patients’ waiting time and eventually raise the level of satisfaction among patients. The proposed solutions succeeded to reduce patients’ waiting time throughout her/his visit due to many improvements to the outpatient clinic management software components.

1.7 Thesis Structure

The study is made up of five well-defined sections, presented in the form of chapter 1, 2, 3, 4, and 5; each chapter starts with a brief introduction and ends up with summary to highlight the main points. The first chapter of this research study elaborates on the aims, objectives, scope, limitations, structure, contributions, and problem statement. It specifies the researcher’s motivation to carry out the study and how this contributes to the field. The second chapter is based on literature analysis
and provides a critical review of outpatient management software, importance of integrating this system within outpatient clinics, in-depth assessment of the outpatient clinical environment and processes for analyzing the benefits of the healthcare system, and analyzing the current availability of these systems within Saudi Arabian clinics.

The third chapter explains the functions of outpatient management software with respect to the patient flow, while maintaining the service quality and reducing the patients’ waiting time within the outpatient clinics of Saudi Arabia. Thus, the main activities taking place within the outpatient clinic are studied in the light of past studies and researches intending to improve the patient flow within the outpatient clinic. The fourth chapter is methodology, which explains the software engineering method and procedure used to analyze the impact of outpatient management software within the outpatient clinics with survey analysis explaining more about the current patient flow problem in Saudi Arabia outpatient hospitals.

Requirement and designing phases have been elaborated. Enhancements have been implemented as a recommendations to new system in outpatient clinics to improve the patient flow. The fourth chapter gives details about the problems in which software engineering phase and proposed solution using simulation or an analytical approach. The study includes interview about the OMS and its impact on the patient flow, in context of comparing the quality of the current and proposed patient flow, and patient flow with the quality of services. The fourth chapter provides the main findings and results of the study. The fifth chapter explains the conclusion and demonstrates the effectiveness of this study to evaluate whether the objectives mentioned in the first chapter have been achieved and to state final discussion on the importance of software engineering within healthcare domain and clinical settings.
CHAPTER TWO: LITERATURE REVIEW
Information system development in the Healthcare industry has been established for many years, and many hospitals have made a lot of investments in Healthcare information systems such as HIS, Laboratory Information System (LIS), Clinical Information System (CIS), Radiology Information System (RIS), Picture Archiving and Communications System (PACS) and so on. The main importance of these systems is to make a different solution for each service department in a hospital, and these different systems can run smoothly in each area. But no single vendor or single information system has all of the information management of a patient in one platform. Therefore, Information systems must communicate with each other to accomplish complex healthcare processes [15].

There are some concerns in the healthcare information system integration, particularly the integration solution of integrating the Healthcare Enterprise launched by Radiology Society for North America (RSNA) and Healthcare Information Management System Society (HIMSS). The researcher makes a try to provide a Service-Oriented Architecture (SOA) and propose an integration service management framework. An example of integrating RIS and PACS in a framework prototype to prove the possibility and benefits of the SOA. Integration of healthcare information systems as a complex task full of experiments has been proposed [15]. Many physicians in the USA rely on paper-based records to document clinical data [16], and do not use Electronic Health Record (EHR) technology. The situation is even more marked in Saudi Arabia [17].

A survey that was carried out to investigate the level of satisfaction regarding the healthcare facilities in Saudi Arabia, opinions of 200 respondents were gathered regarding the services of healthcare in Jubail City. From the results of the survey, it was observed that 38.5% agree that the hospital visits take long time while 30% are not sure and only 31.5% disagree. Whereas in the opinion of 72.5% patients, the services provided by the hospital can be improved [13].
Another survey used the large number of 800 inpatients hospitalized for a period of 3 days to measure the satisfaction of these patients. The level of the satisfaction was high among the patients who paid privately from personal (or family) resources. Moreover, the level of the dissatisfaction was observed in areas like ease of registering, availability of specialists, quality of manners and religion of the staff, quality of doctors, same gender availability in staff, nationality of the staff, the proximity of the facility to their residence, cost of the facilities and the easy use of the facility. However, waiting time is not considered an important factor and consequently, this area remains unaddressed in this study [14].

2.1 Background

This section will describe the hospital information system generally in Saudi Arabia.

2.1.1 Challenges of Implementing EHR in Saudi Arabia

Hospitals in Saudi Arabia have been under tremendous pressure to change and reform their healthcare system development. However, this study reveals lack of successful implementation of EHR systems, as the majority of physicians have no access to EHR in their practice and are still using paper-based records.

The main barrier to the full implementation of Information Communication Technology (ICT) and particularly EHR systems in hospitals is managerial and leadership problems. These include the weakness of the information system infrastructure, implementation strategy, information policy. Physicians attribute the low use of EHR to technical factors (i.e. lack of computer skills, lack of technical support, system limitation) and human factors (i.e. patient privacy, patient direct care) [18].

The common challenges within most hospitals today is the sharing of health data along medical and administrative information systems. This leads to separate data
assets and medical services, all of them include medical data about patients, and contribute to the development of islands of information. There are three main reasons for the existence of information system ineffectiveness in hospitals:

- The complication and diversity of healthcare policies and procedures, the dissimilarity of healthcare organizations like capacity, protocols, financial and traditional side and the predilection of health specialists’ team increase the challenge to develop a single information interface that possibly will successfully help to share patient data with all hospital departments. In most hospitals around the world, development health information systems is mainly based on each department's decision.

- The diversity of the health Information Communication Technology (ICT) market, with its unlimited of specialized software. The ICT companies that have a full functional product for the HIS do not have a specialized modules.

- Legacy information systems are very old and resist any kind of enhancement and expansion or modification [19].

Patients' satisfaction is commonly known as a key performance indicator of the quality of care in healthcare [20]. Patients' waiting time is also measurement of access to healthcare [21]. In United Kingdom and developed countries, the patient experience is an important goal for these countries [22].

Electronic patient records are at present one of the goals of both clinical and clinically cognate research associations. Yet, an organization that requires controlling clinical and non-clinical data is complicated since it needs to handle a variety of different data; not only medical records and non-clinical procedures, but with all managing data from non-electronic medical devices as special laboratory procedures, have to be gathered and stored in a database [23].
2.2 Outpatient Management Software Architecture

The outpatient system supports the integration of different sources of data, administrative, clinical and medical devices, also, Electronic Medical Record (EMR) for cardiology outpatients. The main advantages are to be user friendly, easy to retrieve the history of data, integration of medical devices examinations even performed in the same day of the clinic visit [14].

The integration of outpatient system and cardiology system improves the time needed for health service, clinical laboratories procedures and time needed to build a report to be given to each patient; this report has to be simple to be understood by the patient. Electronic record of patient data makes the organization have more control to follow-up the patient from the clinical and non-clinical perspective. This feature is one of the major advantages additionally for retrieving data needed easily and fast [24].

Generally the various clinical systems use some healthcare domain specific data exchange standards to communicate with each other. For example Health Level 7 (HL7) [25], Digital Imaging and Communications in Medicine (DICOM) [26], and so on. These standards state data structure of communication, with little process to explain how the data exchange should be taken to complete healthcare workflow.

The action of integration profiles is based on notification transactions; it is possible to accomplish workflow management using these actions. A listening manner is used to allow the activities in Integrated Health Exchange (IHE) based systems acknowledged by the workflow environment and thus the workflow running in the workflow engine will proceed to the consistent state [27].

Figure 2.1 shows the workflow management system (WFMS) which is the centralized controller where workflow model is interpreted and enacted. The worklist handler is a module to retrieve the work items from the WFMS and coordinate
distribution of work items. The workflow components are system components developed to execute the tasks that are not contained in the IHE-based legacy systems. The workflow functions existing in a system with proprietary interfaces can be wrapped, e.g., workflow components to execute fee related tasks. Also newly developed system functions can comply with the workflow component specification to make themselves easily to be attached to workflow tasks [27].

Another research is about evaluating some related factors in Human-Computer Interaction (HCI) with healthcare information systems as designated. The results concern the comparison between three types of Input Output devices that can be used by the medical staff who operate medical records in outpatient clinic. A touch screen, a mouse and a keyboard, utilized as standalone devices, have been tested by the medical team, in terms of experience and time needed to fill a sequence of medical electronic forms. The results show that the touch screen appears to be a capable device for the implementation of an efficient and ease of use for medical team when using a medical information system, which leads to reduce the time of action needed by medical staff for providing a medical service [28].
Focusing on patient safety is a worry that arises because of human error as well as other sources. Healthcare systems and software engineering attention must progressively focus on creating strong, consistent, and reliable applications and a framework focused on addressing needs at the point of delivery of care [29].

The integrated medical system can replicate the results from the procedure tests for the clinical software and also give more dynamic information by giving additional parameters, these parameters were not available to the technician before. The procedure time of each patient is reduced both in terms of administrative procedures and clinical results. By using a software engineering method to integrate medical devices to clinical systems, correctness and reliability of procedures are accomplished. The level of medical data presented to the clinician gives a strong and prompt indication of performance [30].

The medical service orders at Emergency Department (ED) are based on illness level. As a result, patients with low priority usually have to wait a long time. In the researcher study, such time would be reduced at Mercy Hospital, without affecting the life of high risk patients. Initially, he studied the patient flow at the ED and designed a model with and without a fast track path. He used a simulation to prove that without a fast track path, 25% of the time will be reduced for patients with low priority without negatively affecting the times of high risk patients. Lack of resources is not always the real problem, The study results have shown that most of nurses' time or doctors' time is being spent filling out medical or non-medical forms and diagrams (lack of software design) [31].

2.3 Related Work

This section explains the reasons behind preferring the use of simulation tool from previous researches, and also the problem of patient flow from different countries and the provided solutions.
2.3.1 Simulation Tool in Patient Flow

The difficulties of the patient flow process directed the researchers to use simulation tool to examine it. Simulation has been used extensively in health care systems for medical research as easily as for planning and administration. Many medical practitioners and researchers have seen that in the processes of a hospital, in general, including the emergency room. The study is conducted to measure the number of ambulances needed at a hospital in Pune, India. The study used a multi-channel queuing to describe the ambulance service at the hospital [32].

The simulation exercise has clearly demonstrated the benefit of using simulation in healthcare and how performance can be optimized using different combination of resources and resource allocation strategies. The simulation study identify the benefits of using simulation in healthcare and how it can improve the performance by allocation of resources strategy [33].

2.3.2 Sirilanka eye Hospital

In another research, the Algiriyage described the problem of waiting time in Sirilanka eye hospitals [34]. He mentioned that the hospitals care about the doctor's time more than patient's time. There are 10 queues in the hospital. He found that the waiting time for the first visit is 13673.8 seconds, and for the second visit is about 6802.62 seconds. The figure shows the queue type inside the clinic and the waiting time. [34]
The researcher also proposed four solutions as shown in Table 2.1, patient appointment scheduling system:

**Table 2-1 Four proposed solutions for patient appointment scheduling system [34]**

<table>
<thead>
<tr>
<th>Solution Rule</th>
<th>Improvement in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1: equal intervals/equal blocks</td>
<td>The first rule improved the average waiting time for 1270.425 second for the first visit and 1320.63 seconds for the second visit. The total time is reduced according to the original flow.</td>
</tr>
<tr>
<td>Rule 2: equal intervals repeating/equal blocks</td>
<td>The second rule is similar to rule 1 but the change is in the block size and the interval time. The time is reduced but there are two steps in the queue taking long time.</td>
</tr>
<tr>
<td>Rule 3: unequal interval repeating/unequal blocks</td>
<td>The third rule is by schedule unequal number of people for each interval. One hour and half repeated. The average waiting time for first visit is 2232.01 seconds and for the second visit 1904 seconds.</td>
</tr>
<tr>
<td>Rule 4: unequal interval repeating/unequal blocks</td>
<td>The fourth rule is similar to rule 3, the difference is in the patient number, the fist visit takes 2639.05 seconds and the second visits takes 1913.32 seconds</td>
</tr>
</tbody>
</table>
Algiriyage proves that the waiting time can be reduced up to 60% by using the above solution.

2.3.3 Taiwan Hospital

Another study is conducted in Taiwan [35], the researcher focuses on the waiting time as a key performance indicator affecting the patient satisfaction and he tries to improve the patient flow by focusing on two factors, scheduled patients and walk-in patients. He used a simulation with 7 different scenarios to calculate the waiting time and the percentage of improvement as shown in Table 2.2.

Table 2-2 The Seven Scenario's of Taiwan Hospital [35]

<table>
<thead>
<tr>
<th>Scenario Number</th>
<th>% of improvement Walk-in Best Results</th>
<th>% of improvement Scheduled Best Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario I</strong></td>
<td>49.5%</td>
<td>63.97%</td>
</tr>
<tr>
<td>Adjusting the Proportion of Walk-in Patients and Scheduled Patients (10% Walk-in vs. 90% scheduled)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scenario II</strong></td>
<td>27.98%</td>
<td>60.23%</td>
</tr>
<tr>
<td>Adjusting Sequence of Walk-in Patients and Scheduled Patients</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scenario III</strong></td>
<td>29.76% to 32.94%</td>
<td>0.52% to 58.33%</td>
</tr>
<tr>
<td>Assigning Front Numbers to Walk-in Patients and Later Numbers to Scheduled Patients after 60 to 120 min from clinic starting time</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scenario IV</strong></td>
<td>53.24% to 86.95%</td>
<td>53.24% to 58.33 %</td>
</tr>
<tr>
<td>Assigning Front Numbers to Scheduled Patients and Later Numbers to Walk-in Patients after 60 to 120 min from clinic starting time</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scenario V</strong></td>
<td>21.69% to 51.40%</td>
<td>11.84% to 69.79%</td>
</tr>
<tr>
<td>Assigning Some Front Numbers to Walk-in Patients and Later Numbers to Walk-in and Scheduled Patients (Front 5 to Front 20)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Scenario VI
Assigning Some Front Numbers to Walk-in Patients and Assigning Later Numbers to Walk-in and Scheduled Patients with Different Patient Sequencing

<table>
<thead>
<tr>
<th>Scenario VII</th>
<th>Adjusting the Late Rate and Applying a Late Policy for Late Patients</th>
<th>No significant Improvement</th>
<th>No significant Improvement</th>
</tr>
</thead>
</table>

2.3.4 Chicago Hospital

A simulation study of an Ears, Nose and Throat (ENT) clinic at the University Of Illinois Medical Center in Chicago has been achieved [36]. In the first scenario, the researcher adds another resident doctor to the system who can serve all patient types. In the second scenario, the researcher changes the appointment policy. The first scenario is measured to show that the alternative appointment schedule has a better effect on reducing the patient waiting times compared to the resource alternative scenario. From the data collected at the clinic, we can see in Table 2.3 that the first patient type for both patients’ categories need less service time in the examination stages if we compare it with the other type.

The test of otology patients typically takes more than an hour. By changing the appointment policy, we can see in the Table 2.3 that there is an improvement in the first and second scenario. Please see the table below that present the process type with average total time before and after applying the policy. Based on the results from the simulation for 100 repetitions, the average waiting time of the patients is reduced about 10.38% at the initial examination stage. Therefore, the time is reduced between 24.15% and 18.4% at the second examination stage [36].
At the same time, In [36] the problem from software engineering point of view was not solved. The research is valuable but it sees the problem from one side only, which is the scheduling patient time, resources and changing the patient order [36].

The healthcare scheduling systems are usually used for patient appointments in order to increase the healthcare resource utilization. The main objective of scheduling systems is to provide a better service by giving the patient a specific time to be served, but at the same time scheduling system cannot resolve all the patient daily service problems. Gallucci [37] gives a definition to the appointment delay term. He defines it as the time between patient requests until the appointment scheduled. But the bigger problem is where the patient cancelled the appointment or did not show up [38]. Nan Liu proposed two types of appointments to solve the outpatients scheduling system issues, no-show and patients cancellation of their appointments. The first one is dynamic scheduling and the other one is static, managing the appointment depends on the patient-no show probabilities [37].

2.3.5 Korea Hospital

Another study conducted in Korea [39], in a large scale general hospital. There are many doctors who use share resource but they have a problem in the appointment scheduling software.

For appointment scheduling problems, the measures are patient’s waiting time (W) and staff’s over time (O). This study also implements the two measures in evaluating the efficiency of appointment schedules system. A simulation model was created using ARENA™. The simulation model is a precise copying of the actual environment of the department. When doctors share public resources, separate

<table>
<thead>
<tr>
<th>Process</th>
<th>Average Total Waiting Time (minutes)</th>
<th>Improvement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>45.829</td>
<td>N/A</td>
</tr>
<tr>
<td>First Scenario</td>
<td>43.403</td>
<td>5.29</td>
</tr>
<tr>
<td>Second Scenario</td>
<td>38.947</td>
<td>15.02</td>
</tr>
</tbody>
</table>
doctor’s decision disturbs the patient flow of other doctors. It is essential to know the existence of dependency between patient flows, and appointment scheduling in the hospital. The simulation shows that doctors working in the same session have effects on each other. Thus, the patient service time flowing within the system is affected [39].

2.3.6 Hong Kong primary care hospital

In this study, the researcher tries to solve the patient long waiting time in Hong Kong primary care hospital. The methodology used to identify the issue is the survey. The researcher realized that there were two reasons for long patient waiting time, the first one is season's diseases which increase the volume of patients and the staff turn overrate for the primary clinic. This research did not check the software of the outpatient primary health care clinic [40].

2.3.7 China hospital

The research was conducted in China studying patient flow in a hospital [33]. Patients go through a sequence of processes from registering at the reception area to discharge or admission to inpatient. It is essential to clarify that some patients may have repeated their process before the discharge. The study proposed three models to demonstrate how different strategies can be used to improve the performance of the outpatient software. In Model A, doctors sharing patient. In this scenario, it was proposed that any available doctor can see any patients from the system at the first examination. In Model B, adding volunteers in this scenario. Five volunteers were introduced to the system. These additional resources reduced waiting times significantly. Model C: Changing volunteer priorities, by changing the location of volunteers, better utilization of resource was achieved [33].

2.4 Queuing Theory for Patient Flow

There are a variety of applications of queuing theory in healthcare with waiting time and service utilization analysis and appointment systems. The performance of healthcare services are only likely to lead the improvement of poor quality of service
and are unlikely to be a successful approach to having and reducing healthcare costs [28]. Mr. Bevan said "It has been found that the approach to managing queues in a healthcare system through arbitrary targets and performance ratings is problematic [42].

Using a queuing in outpatient department is not new; the difference is on the way of applying it. In [43] study, the outpatient department has two queue types, single service model and multi service model, the author used Matlab for analysis. Queuing system data, he found that by adding more windows or counters, this will reduce both the service time and the waiting time [43].

In the UK, the study is about managing queues in the British National Health Service (BNHS), focusing on satisfying patients regardless of the effects on the staff, the most important assets in the BNHS organization. This paper has focused on studying the link between the service time of staff and the waiting time of patients and therefore, between the satisfaction of staff with service time and patient satisfaction with waiting time. Depending on data, the model for estimating the satisfaction of staff with service time is implemented. This model is linking the staff satisfaction and patient satisfaction, called as Effective Satisfaction Level (ESL). The study assumes that the patient satisfaction can be improved if the staff is satisfied. The results of ESL showed that the ideal service time is near to or equal to the actual service time with the corresponding actual waiting time also close to or equal to the expected waiting time. This means that it is likely to be expected from doctors and nurses for a preferred level of patient experience [44].

Existed queuing researches did not provide a software solution to the waiting time problem. The previous studies focused on adding more service windows or counters which will have a positive effect on services time. Another point is the queue order of the patients in the clinic is either First In First Served (FIFS) or Last In First Served (LIFS), so what is the benefit of appointment time and how we can measure waiting time if the time factor is missing?
Table 2.4 shows that many hospitals around the world proposed solutions to overcome the long waiting time problem in outpatient clinics such as Chicago, China, Siri Lanka eye, Taiwan, Hong Kong and Korea Hospitals. Some of them succeeded to reduce the waiting time in their clinics by 15%, 78%, 60%, 50% respectively. Their solutions mainly depend on adding more human resources in terms of doctors or volunteers or by changing some business or management policies. The solutions presented in this paper improve the waiting time by enhancing the software used to manage outpatient clinics services.

<table>
<thead>
<tr>
<th>Country</th>
<th>Solution</th>
<th>% Improvement</th>
</tr>
</thead>
</table>
| Chicago Hospital| 1- First scenario the research added another resident doctor to the system who can serve all patient types.  
2- Second scenario the research changed the appointment policy. | 15%           |
| China Hospital  | The study proposed three models to demonstrate how different strategies can be used to improve the performance of the outpatient patient flow.  
Model A, doctors sharing patient. In this scenario, it was proposed that any available doctor can see any patients from the system in the first examination.  
Model B, adding volunteers in this scenario. Five volunteers were introduced to the system. These additional resources reduced waiting times significantly.  
Model C: Changing volunteer priorities, by changing the location of volunteers, better utilization of resource was achieved | 78%           |
| Siri Lanka Hospital | This study analyses different queues which create bottlenecks in outpatient Department at national eye hospital in Sri Lanka and critically evaluate several appointment scheduling rules with the help of a | 60%           |
A simulation model was used to come up with a solution which minimizes the total patient waiting time.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taiwan Hospital</strong></td>
<td>The researcher focuses on the waiting time as a key performance indicator affecting the patient satisfaction and he attempted to improve the patient flow by using mixed-type registration. He used a simulation with 7 different scenarios to calculate the waiting time and the percentage of improvement</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Hong Kong Hospital</strong></td>
<td>Survey</td>
<td>N/A</td>
</tr>
</tbody>
</table>
CHAPTER THREE: OUTPATIENT MANAGEMENT SOFTWARE IN SAUDI ARABIA HOSPITALS
3.1 Overview

This chapter will give an overview about the research approach and methodology used to identify the problems affecting the patient flow in Saudi Hospital. The study explains the method used to analyze the impact of software engineering on the outpatient clinical settings in Saudi Arabia Hospital. A case study has been selected to identify the obstacles that stand-in the way of patient flow in the healthcare facility. The case study –called KSA-hospital - is one of Saudi Arabia's Ministry of Health (MOH) biggest hospitals using state of the art modern technology. The outpatient service in KSA-Hospital benefits a huge number of patients in different medical specialties, with around 1300 clinic visits per day excluding medical procedure visits. The high management would like to increase the patient satisfaction by minimizing the clinical visits time. This includes patient arrival, nursing assessment, physical examination, and other treatment or procedures which vary from specialty to specialty.

3.2 Outpatient Fishbone Analysis (cause and effect).

Fishbone Analysis is a diagram created by Kaoru Ishikawa in 1968 showing the root causes of a specific event [45]. Including:

- **People**: Anybody involved in the process
- **Methods**: How the process is executed and the specific requests for doing it, such as policies, procedures, rules, regulations and laws
- **Materials**: basic materials, parts, pens, paper etc.
- **Measurements**: Data produced from the current process used to evaluate the quality of the process.
- **Environment**: The surrounding nature or artificial component, like the area, time and temperature.
- **Machines**: devices, computers, tools, etc. required to achieve the work
The cause and effect diagram is used to explore the behavior of the process and it is used for people involved in the process. [46]

The steps of Ishikawa are divided to three types:

1- The dispersion analysis type.
2- The production process classification type.
3- The cause enumeration type.

The researcher has listed all possible causes that effect the process by using a brainstorming session with the stakeholder [46]. Figure 3.3 shows the main factors that affect patient flow in outpatient clinics. This information has been collected from interviewing the manager of outpatient clinic.

![Fishbone analysis for the root causes that effect patient flow](image)

**Figure 3-1: Fishbone analysis for the root causes that effect patient flow**

The most important factors in KSA- hospital which affect the patient flow are:
3.2.1 Method or Process

Figure 3.4 shows the scenario of patient flow in KSA- hospital's outpatient clinics which is as follows:

1. Patient checks-in using self-service machine or at reception.
2. Patient waits in the waiting area for vital signs assessment.
3. Patient is called in the vital signs assessment.
4. Patient waits in the waiting area for clinic to see the doctor.
5. Patient is called to the clinic.
6. Patient takes the next appointment from the reception.

![Figure 3.4: The patient flow Process in outpatient clinic](image)

Figure 3.5 shows the same scenario in outpatient clinic layout. The patient flow process has not been implemented yet in KSA-Hospital policies. This issue has become a center of conflict between outpatient department staff and the medical staff; The outpatient staff knows general rules about patient flow, but unfortunately it keeps on changing on a daily basis.
3.2.2 People

In the term of people, there are two problems adversely affecting outpatient flow. The first one is lack of resources, for example in Figure 3.5, there is only one patient reception desk with two staff serving more than 121 patients per day per floor. This problem makes patients stand in long lines in front of patient reception and this lengthens the time of service for each patient. The second problem is software poor program flexibility and lack of training; the medical staff refuse to use any new software, either because of lack of training or they are resistant to any change.

3.2.3 Measurement

Measuring the quality of health care is essential since it states how the health system is executed and to which level. Measurement can be used to improve healthcare organization by avoiding the misuse of health care capacity and increase patient safety. Measurement can detect what happens in health care and can translate it to a meaningful number called key performance indicator. The outpatient management
does not have a dashboard to help them monitor the waiting time of the patients. This leaves the patient's waiting time neglected and unattended for. Unfortunately, the waiting time is not a key performance indicator for outpatient departments.

3.2.4 Management

The appointment booking processes take a long time. The appointments are given from one location at one reception desk. There are always delays in the booking process resulting in patient dissatisfaction and long waiting time. Sometimes clinic preparation is not always completed resulting in too much wasted time. The appointment desk is the most important station in the journey to the clinic. Therefore, a prompt and efficient solution should be provided.

For the documented policy, it has been found that patient flow policies are not properly implemented in the outpatient clinics. For example, the patient comes any time before the appointment time while it is clearly indicated in the appointment slip that patient's arrival should be thirty minutes before appointment time.

3.2.5 Environment

The clinic layout design of patient flow is not made according to the logical flow order. However, it is mainly based on internal departmental resolutions. Figure 3.6 demonstrates the physical layout of floor two in the outpatient building illustrating the arrangement of number of clinics with the diverse services in the KSA-hospital. The patient has to go to a different corridor for the vital signs rooms, like corridor 4. Then, s/he has to come back to corridor 2 for the rest of the services as pharmacy, laboratory, and patient reception, while the clinic and the special services are inside protected corridors with electronic access doors.
As any organization, the services depend on its resources and capacities. For example, the KSA-Hospital has a huge number of physical examination rooms, procedure rooms, vital signs rooms and medication rooms and at the same time due to misuse of current resources the capacity of patient service is limited. Also, the disorganized rooms and clinics both impact the quality of the services provided. Most of medical procedures for patients are made without appointment. So, the medical staff cannot predict the number of patients in any day; sometimes they are overloaded and sometimes there are few patients. Another issue is related to share resources. For example, each clinic owns its medical equipment used in one or two days per week, while the other clinics can use the same equipment on the other day. But this kind of collaboration is missed.

Another problem is about the direction signage; the current outpatient building does not have proper direction signage that helps patient to find the needed location easily without asking for help. Surprisingly, there is no information desk to guide the patient to the proper place. In addition, the corridor doors are closed by the security team. The outpatient management has decided to close the doors to prevent any
consultant interruption. Thus, the nurse is responsible for opening the door and allowing the patient entrance.

3.2.6 Machine

In the fishbone diagram analysis method, the machine category means the technology used in the outpatient building whether it is software or hardware. In this research, the focus will be on software direct impact on the patient waiting time from software engineering point of view to be illustrated in the following section.

3.3 Outpatient Management Software in KSA-Hospital

The KSA- Hospital has a Hospital Information System (HIS) that contains many systems integrating with each other. One of these modules is OMS which contains sub software as shown in Figure 3.5. The (OMS) module usually uses different applications and platforms because different vendors provide them. (OMS) applications are integrated using Service Oriented Architecture (SOA). The software exchanges the patient and appointment data using web service. The web service is located in middle ware called Integration Engine (IE).

Figure 3.7 shows the outpatient software architecture, which includes three main services: opening file on the left side, outpatient service in the middle of the architecture and closed patient file on the right side. The patient flow process starts from opening a new file in the KSA-Hospital service by applying a request in referral software or a visit to the Emergency Department
After approval of the medical committee. The file is opened and activated. Then, the patient file is transferred to the outpatient clinics for consultation services. The outpatient software includes a massive number of modules. Like scheduling system, queuing system, room management system, medical record archiving system, computerized physician order entry system, point of care system, medical imaging system, and heart beat analysis system, diagnostic system and radiology information system. Those are just few examples of the current used systems in the outpatient department in KSA- Hospital. When the patient ends the medical service, his file is transferred again to the referral software in order to deactivate or close the patient file or close the service.

As shown in Figure 3.6, the data flow starts with opening patient file and ends with service closed in the KSA-hospital after several visits. The data flow starts with accepting the patient by the medical committee inside KSA-Hospital, the case referred from all KSA hospitals using referral system. Then after patient is accepted, the data is moved using (SOA) to the registration system in order to open a file or medical service profile. Then, the patient receives an appointment message to confirm the appointment date and time. Finally, in the appointment date the queuing system imports all appointments with its details early morning. The patient uses self-service machine to register appointment arrival or check-in to the hospital. Some of the health providers in other health sectors record the patient arrival time and status manually because OMS cannot track the patient flow.
The modules in OMS include many actions. These modules are used by health care provider staff including technicians, physicians, nurses and administrators who care about the quality of the provided service to the patient. The outpatient software OMS can execute actions such as appointment, patient's arrival, medical orders, laboratory service, pharmacy service, medical imaging service, Emergency Department (ED) and admission.

Figure 3.7 shows the queue flow of outpatient data as processed by more than one system used by KSA-Hospital staff. The letters A, B, C, and D represent the flow steps of the patient as s/he arrives at the clinic. A is the reception desk step; B is the nurse assessment step. The nurse usually uses a manual documentation to record the patient data. Then, the data is scanned and archived in the medical record system. C is the examination room or clinic step. The physician uses multiple software in his/her clinic. D is a procedure step, whether internal or external as used by technician.

The nursing documentation is made manually. The internal procedure and treatment orders are also manually scheduled by nurses inside each clinic.
Figure 3.8 shows the outpatient software identifying a type of appointment called overbooked. Based on the case study, the type of appointment does not have a specific time. This type could represent more than 30% of the total number of appointments. In the queuing system, it is very difficult to calculate the waiting time since this has low priority in service; the patient does not know this information. Another problem is that the clinic does not start on time; the first appointment is at 8:30 AM, while actually the clinic mostly starts after 9:30 AM, which has a direct impact on waiting time.

Figure 3.10 shows the difference between planned clinic and actual clinic time, in the planned clinic, the clinic has 100% booked patients and 30% overbooked patients. The clinic should start at 8:30 AM and closed at 4:30 PM. The actual data shows that the clinic starts mostly at 9:30 and there are 70% of booked patients. 30% of overbooked patients are seen without specific time and 10% of patients sometimes come without appointment. The impact of clinic starting time is shown in Figure 10 B.
3.4 Time Definition in Outpatient Clinic System

As shown in the Figure 3.9, there are five service times and three waiting times.

3.4.1 Service Times in Outpatient Clinic

3.4.1.1 Arrival Time (AV)

When the patient physically arrives at the clinic and registers her/his arrival using the self-service machine. The software automatically detects the time and prints a ticket that has the queue number, arrival
time and appointment time.

3.4.1.2 Vital Service Time (VTS)
The time required to assess the patient by the nurse. This has two parts: The first one is vital signs part using a biomedical device. In this part, the nurse also takes the height, the weight and temperature. The second part serves to document patient information using medical forms.

3.4.1.3 Clinic's Service Time (CST)
The time from patient arrival to the clinic until departure. The consultant first opens the patient file to review the medical record. Then s/he asks the patient for the physical examination. And finally s/he orders the required medical treatment in the Computrized Physician Order Entry (CPOE) software.

3.4.1.4 Appointment Service Time (AST)
This comes when the patient is discharged from the clinic and then s/he goes to take his next appointment from the reception.

3.4.1.5 Discharge Time (DT)
The discharge time is the last time after creating the patients next appointment.

3.4.2 Waiting Times in Outpatient Clinics

3.4.2.1 The first one called Vital Signs Waiting Time (VWT). The time between check-in until the nurse calls for vital signs service.

3.4.2.2 The second waiting Time is Clinic Waiting Time (CWT) .The time between vital service and clinic service.

3.4.2.3 The Third waiting time is Appointment waiting time (AWT). The time between clinic service and appointment service.
The biggest challenge is to identify the reasons behind the long waiting time in the outpatient clinics since this waiting time element is the most important measure that helps to increase patient satisfaction, resource utilization, and overall clinic management. Figure 3.10 shows the sequence diagram of the patient flow inside the clinic. The sequence diagram helps to understand the order of the flow and the expected service time in each step.

As a further advanced step, this paper analyzes the patient flow in steps and addresses the "bottlenecks" that have a direct or indirect impact on service time.

3.5 Satisfaction Level in Saudi Outpatient Hospitals

In this study, the researcher uses fishbone analysis and survey methods. The fishbone is used to study the process from inside the outpatient management and find the root causes problem. However, the survey is used to measure the satisfaction level of
patient from outside perspective and it also helps to identify if there is a real problem and where the majority of problems lie.

The questions are designed according to patients flow in the clinic. Moreover, if the patient visits the hospital regularly, his opinion on nursing service time (VTS) or clinic service time (CST) is written down without affecting the quality of medical service. The clinic waiting time is measured in this survey. The patient opinion helps the hospital to improve the services.

The survey was sent using web link and site visits to hospitals in Riyadh. The number of respondents is 175 patients. Table 3.1 shows the results of a survey conducted to find the age of the respondents in the study. It has been concluded that highest percentage of the respondents fall under the age category of 26-35 years, thus constituting 41.1% of the total respondents. 31.4% of the respondents in the survey were under the age of 16-26 years. The least percentage of the respondents was those who were older than 56 years.

Table 3.1 Age group for the Satisfaction Survey

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 16 to 25</td>
<td>31.4%</td>
</tr>
<tr>
<td>From 26 to 35</td>
<td>41.1%</td>
</tr>
<tr>
<td>From 36 to 45</td>
<td>19.4%</td>
</tr>
<tr>
<td>More than 45</td>
<td>8.0%</td>
</tr>
</tbody>
</table>

Table 3.2 shows the gender distribution of the participants in the survey. An analysis of those who took part in the questionnaire survey reveals that the majority of respondents were female. Therefore, the results are based mainly on the satisfaction of females. It can also concluded through the frequency distribution that 39% of the respondents in the survey were males whereas 61% of respondents were females.

Table 3-2 Gender group for the Satisfaction Survey

<table>
<thead>
<tr>
<th>Gender Category</th>
<th>Response Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>39.4%</td>
</tr>
<tr>
<td>Female</td>
<td>60.6%</td>
</tr>
</tbody>
</table>
Table 3.3 explains the educational level of the respondents in the survey. From the frequency distribution and the data analysis, the results of the survey reveal that more than half of the respondents in the study were Bachelors. The next highest percentage of the educational level of the sample under survey was Master and Ph.D. category respectively, and these constitute 18.5% of the total population. The numbers of skipped questions in the study were two only.

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Response Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>intermediate school</td>
<td>2.9%</td>
</tr>
<tr>
<td>high school</td>
<td>14.5%</td>
</tr>
<tr>
<td>Diploma</td>
<td>11.0%</td>
</tr>
<tr>
<td>Bachelor</td>
<td>53.2%</td>
</tr>
<tr>
<td>Master and PH.D</td>
<td>18.5%</td>
</tr>
</tbody>
</table>

The questionnaire was designed to measure the satisfaction level of patients visiting outpatient clinics. The survey questions and their results are as follows and a summary is provided in Table 3.4.

1. Do you take the medicine right away after your appointment?
   In response to this question, it has been found that majority of the respondents strongly agree that they take medicine right away after appointment. The number of the respondents in the survey who accepted this statement was 75%, while only 7% they delayed taking medicine to another day.

2. Is there any one from your relatives who helps you to get your Medical services?
   Responses to this question were evenly distributed; 31% of the patients needed a help from their relatives in their visits. 39% did not need any help, and only 30% sometimes needed a help.
3. How is your ability to use the self-service machine for check-in service (like the one in the airport)?
   There was no clear response that could identify maximum inclination to use machines. From the analysis of the data; there are 40% respondents who believe that they can use this service while 20% of respondents do it rarely. 14% respondents believe that they are unable to use it.

4. Do you visit hospitals, if you do not have an appointment, for example to complete procedures, get a report or appointment, for instance?
   20% respondents believe that they visit hospitals if they do not have an appointment, whereas 44% in the survey believe that they rarely do it. However, 21% respondents say that they never do it. Therefore, the results of the survey explain that majority of respondents do it on the basis of appointment.

5. Do you follow the nurse’s explanation for the expected waiting time?
   66% of respondents say that they never follow nurse’s explanation for the expected waiting time. 23% of respondents say that they do, whereas 21% of respondents say that they do it sometimes.

6. Do you follow the nurse’s explanation for the next step and what you should do?
   36% of respondents say that they know from nurse’s explanation for the next step. 37% of respondents say that they do it rarely whereas 27% of respondents say that they do it sometimes.

7. How well did the medical consultant explain your case during the physical examination?
   From the data and the frequency distribution of the survey, 26% respondents say their consultant explain their case during the examination, whereas, 26% say that their consultants do it most of the time and 32% believe that their consultant do it sometimes.
8. Have you waited for your appointment for more than one hour?

34% agree that they sometimes wait more than 1 hour and 18% disagree. However, 47% say they always wait for more than 1 hour.

<table>
<thead>
<tr>
<th>Table 3-4 Patient visit survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction Questions</td>
</tr>
<tr>
<td>1. Do you take the medicine right away after your appointment?</td>
</tr>
<tr>
<td>2. Is there any one from your relatives who helps you to get your Medical services?</td>
</tr>
<tr>
<td>3. How is your ability in use the self-service machine for check-in service?</td>
</tr>
<tr>
<td>4. Do You visit the hospital if you do not have an appointment? To complete procedures, get a report or appointment, for instance.</td>
</tr>
<tr>
<td>5. Nurse’s explanation for the expected waiting time</td>
</tr>
<tr>
<td>6. Nurse’s explanation for the next step and what you should do.</td>
</tr>
<tr>
<td>7. How well did the consultant explain your case during the examination?</td>
</tr>
<tr>
<td>8. Have you waited for your appointment for more than</td>
</tr>
</tbody>
</table>
Table 3.5 shows patient satisfaction according to the service type provided. Question number 1 is about the time taken to get to the reception desk to get a new appointment, 38% are between satisfactory and extremely satisfactory, 42% think that the time is accepted for them, 13% are not satisfied, but only 7% are extremely not satisfied. Question number 2 is about the reception service time. 49% are satisfied, 41% accept the time taken by the receptionist and 9% are not satisfied which means that the problem of waiting is not in the reception desk. Question number 3, 45% of patients are satisfied with the nurse service time, 38% accept it, and 18% of patients are not happy.

Question number 4, 29% of the patients think that the number of patients who wait for one consultant is reasonably satisfactory, 37% are ok and 35% are not satisfied. Question number 5, is about waiting for vital signs service, with 33% satisfied, 44% ok, while 24% are not satisfied. Question number 6, the waiting time before the second call, 33% are satisfied, 34% are ok and 32% are not satisfied Question number 7, the overall visit, 30% are satisfied, 36% are ok and 34% are not satisfied at all.

### Table 3-5 Satisfaction level of Clinic visit in outpatient clinic

<table>
<thead>
<tr>
<th>How Satisfied you are:</th>
<th>Extremely satisfied</th>
<th>Satisfied</th>
<th>Barely satisfied</th>
<th>Not satisfied</th>
<th>Extremely not satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The length of time you had to wait to get a new appointment from the Reception.</td>
<td>11%</td>
<td>27%</td>
<td>42%</td>
<td>13%</td>
<td>7%</td>
</tr>
<tr>
<td>2. The Reception service time.</td>
<td>12%</td>
<td>37%</td>
<td>41%</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>3. The nursing service time.</td>
<td>14%</td>
<td>31%</td>
<td>38%</td>
<td>14%</td>
<td>4%</td>
</tr>
<tr>
<td>4. Number of waiting patients for one</td>
<td>12%</td>
<td>17%</td>
<td>37%</td>
<td>23%</td>
<td>12%</td>
</tr>
</tbody>
</table>
physician.

5. The length of time, you spent waiting before the first call.

6. The length of time, you spent waiting before the second call.

7. Your visit overall.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Response Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival time</td>
<td>43.2%</td>
</tr>
<tr>
<td>Appointment time</td>
<td>56.8%</td>
</tr>
</tbody>
</table>

For the following question, we asked the patients how they counted their waiting time, 43.2% say from the arrival time, 56% say from appointment time as shown in Table 3.6.

Table 3-6 waiting time starting time

<table>
<thead>
<tr>
<th>When do you start counting your waiting time?</th>
<th>Response Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival time</td>
<td>43.2%</td>
</tr>
<tr>
<td>Appointment time</td>
<td>56.8%</td>
</tr>
</tbody>
</table>

Table 3.7, 56.8% of patient agree that the clinic management informed them to come on time, 43.2% say that they are not informed to come on time.

Table 3-7 confused in appointment time

<table>
<thead>
<tr>
<th>Have you been informed to come early to your appointment regardless of your appointment time?</th>
<th>Response Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>56.8%</td>
</tr>
<tr>
<td>No</td>
<td>43.2%</td>
</tr>
</tbody>
</table>

The survey shows that the patients are not totally satisfied with outpatient services, since only 20% of patients were reported satisfied. The patient cannot identify if the time of his services start from arrival time or from appointment time. This question helps to find the miscommunication between clinic management staff and the outpatient staff. Also, the patients who wait for less than one hour constitute only 18% of patients. This guides to an important question. What is the reasonable time?
The reality is there is no clear measurement due to problems that we will discuss in the next chapter.

In the next chapter we will address some of the problems and their proposed solutions. These solutions are meant to improve patient flow and the way to implement them. The problems that will be addressed include overbooked problems, the number of accepted patients for outpatient care, communication between health providers, late clinic starting time, patient no-show problem and early coming patients.
CHAPTER FOUR: KSA HOSPITAL

CASE STUDY DISCUSSION,

IMPLEMENTATION AND ANALYSIS
6.1 Overview

As explained earlier, this research has figured out several problems affecting the patient flow. Such problems include overbooking, the number of accepted patients for outpatient care, communication between health providers, late clinic starting time, patient no-show problems and early coming patient problem.

The focus will be on the problems as per (SDLC) phases, some of which are design problems, and requirement analysis problems. Moreover, by using the analytical study or simulation, the study will show the impact of solving these problems.

6.2 Simulation Tool

Simio [47] is a tool for building and executing dynamic any models of process. Simio acts out and displays a 3D animation of the behavior of system over time. It helps to see proposed changes in the system in simulation before building these changes in real system. The proposed solution has not been implemented in reality. It can be an existing systems that requires some changes. In either case, the modeling process can provide significant benefits. Because the cost of implementation of legacy software is very high, the simulation model is used to verify that the software will perform as expected[47]. So, the researcher has proposed to see the impact first in the simulation and then design the proposed model in real software. The sample of data used in analysis is derived from referral system, queuing system, booking system and human resources system. The booking data exported is for one clinic for a period of three months. The referral data presented is for a period of three years 2012, 2013, 2014 and for human resources a real time data has been taken. Steps of building outpatient process in simulation are as follows:

1- Create a process using the ready-made component inside Simio:
   - The source component represents the number of patients that visited the
hospital
• The server component represents the service type like vital signs service or clinic service
• Sink is the ending of the service.
• Create a time between services that presents the time before the service and during the service and after each service.

2. Upload 2000 records that are extracted from queue database.

3. Change the configuration based on the problem. As an example, the start time of the clinic assumed to be 8:30 to see the impact on the clinic waiting time, change the arrival time to be 7:30 for the first appointment to see the impact on the vital waiting time.

Figure 4.1 shows the problem findings are ordered according to the waiting time from highest to lowest and the source of the systems causing that impact on the waiting time.

Figure 6-1 Problem and affected software category
Chapter three has considered some of root causes of the problems using fishbone analysis. This includes several problems and the study focuses on each problem from software engineering point of view. That does not mean it is the only problem that affecting patient flow. The current research has concentrated on the problems causing the highest or unmeasured waiting time, including

1. Appointment type problem
2. Ticket Numbering Problem in Queuing Software
3. Doctor Clinic Reporting
4. Early Coming Patients.
5. Missing Flow Problem (Doctor distribution list)

6.3 Outpatient Software problems from Software Engineering point of view

This section will present the analysis of the five problems affecting the patient flow in outpatient clinics and the proposed solutions.

6.3.1 Appointment Type Problem

In this section, the study will focus on proposing solution for the first problem affecting the patient flow. How it was started and the impact level on waiting time and finally the solution for this particular problem.

6.3.1.1 Proposed Solution for Appointment Type Problem: Gathering Requirement Phase

KSA-hospital outpatient management software has three types of appointments: booked, overbooked and walk-in.

- **Booked** is an appointment that contains the appointed clinic, consultant's name, specialty, and appointment time.

- **Overbooked** appointment is similar to the booked one but without specifying the time of appointment. The appointment time is indicated as AM for the morning clinic and PM for the afternoon clinic.
• **Walk-in** is an appointment given to the patient in the same day and limited for emergency cases.

In the case study, KSA-hospital receives around 1300 patient visitors for outpatient services per day; it is very difficult to manage them without queuing system, the queuing software started in the fourth quarter of 2014. This system gives the first priority to the booked appointment, the second priority to the overbooked and the third priority to the walk-in. Figure 4.2 shows the patients who wait more than 60 min for the month January of 2015. The average waiting time for booked patients is 100 minutes and 133 minutes for overbooked patients.

![Figure 6-2 Average Waiting Time for Booked and Overbooked Patients in January 2015](image)

This research has found that there are two main reasons for overbooked appointment type. The first reason is the growing number of referral patients and the second reason is the relatively high percentage of no-show patients.

• **Referral Patients**

Every day, the KSA-hospital receives 300 referral cases. The accepted cases are around 127 per day for outpatient care. The Eligibility Department through the referral system exchanges the accepted files to Outpatient Department through registration system to generate a file. Then, Outpatient Department creates first appointment by using schedule system based on the
KSA- hospital's policy; the patient should be examined within two to three weeks maximum from the accepted date.

Figure 4.3 shows that in year 2012, the average number of accepted cases was 2406, but in year 2013 it was 2425 showing 1% increase and 32% increase in 2014 to reach an average of 3551 cases per month.

![Figure 6-3 Number of accepted referrals for outpatient care from 2012 to 2014](image)

- Patient No-show

No-shows are considered a big problem for any healthcare provider since they try to have the best utilization of resources in the clinic. The estimate percentage of the no-show patients is different from country to country. Some sources say that it is between 7 and 12 percent. In year 2000 in the U.K, a survey showed that the country had around 17 million missed appointments with total estimated loss of $240 million [49].

In 2005, KSA- hospital applied the Health Information System and started the main modules including the emergency system, the outpatient module system, and the admission module system. Two years later, the outpatient management found that the number of patient no-show was high in 2007 and 2009. The no-show started with 37% in 2009. As a solution at that time, KSA-hospital applied the reminder system to remind the patients of their appointment 48 hours before the appointment time. This solution helped to reduce the percentage of no-show to 26% for the year 2014.
Table 4.1 shows the total number of appointments was 1300 visits per day for 2014; the new appointment requests from referral system were 127 per day, and the no-show patients were 338 per day. However, still 338 wasted appointments were not accepted by the high management. The growing number of new appointments from referral system and the no-show problem directed KSA-hospital to use the overbooked appointment type to utilize the clinic time and resources.

<table>
<thead>
<tr>
<th>Outpatient Clinic Appointments Capacity</th>
<th>Referral patients</th>
<th>Patient No Show</th>
</tr>
</thead>
<tbody>
<tr>
<td>1300</td>
<td>127</td>
<td>338</td>
</tr>
</tbody>
</table>

Overbooked or some times called as an adds on appointment type is usually used in a hospital booking system to maximize the clinic utilization by accepting the same percentage of no-show as overbooked. For example, in clinic A, if the no-show parentage is 26% for the last month, the system will accept only 26% of appointment as adds-on overbooked during the next month.

When KSA-hospital put into action the overbooked solution, they missed the appointment time in the appointment slip. It shows AM or PM appointment only; the AM means from 8:00 AM to 11:59 a.m while the PM means from 1:00 pm to 4:30 pm. This issue makes the patients willing to come early because they do not know exactly when they will be examined by their doctors. The doctor also gives the patient overbooked appointment slip with a small stamped paper if the booking system is fully booked, which makes it difficult for the outpatient staff to measure the load of patients per day.

6.3.1.2 Proposed Solution for the Appointment Type Problem: Design Phase

After analyzing the problem, this study puts forward a proposed solution that
can achieve the same management goals by utilizing all appointments due 48 hours from the appointment time. The idea of this proposal is to deal with overbooked appointments as appointment waiting list and send a short message to the patients using the reminder and appointment confirmation service. The confirmation mechanism helps to ensure the patient will report to the clinic. In case the patient is unable to visit the clinic, he/she can send cancellation note to KSA-hospital confirmation gateway.

Figure 4.4 explains the scenario of the proposed solution:

1. Using a database trigger, the interface engine will read appointments details daily and send out the appointment list 48 hours before the appointment time.

2. The patient will receive a reminder short message SMS with option to reply to that message.

3. The patient will send cancellation if s/he is unable to come.

4. Deletion of the appointment in the booking system.

5. Replacing one of the overbooked appointments in the same slot.

6. Booking Software will send new appointment time to the Integration Engine (IE)

7. Integration Engine (IE) will send a confirmation message to the patient to inform her/him that her/his overbooked appointment has been converted to a booked appointment with specific time.
6.3.1.3 Proposed Solution for Appointment Type Problem: Post-Implementation Phase

To verify the solution, a sample of 94 appointments in one day has been taken, covering ten clinics and 11 consultants. The number of no-shows for that day was 40, which means 43% of patient did not show up and the consultant examined only 57% of patients. The overbooked appointments on that day were 19 appointments as shown below in Table 4.2.

<table>
<thead>
<tr>
<th>Table 6-2 Sample clinic data for January 4th 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Appointments</td>
</tr>
<tr>
<td>Number of Clinics</td>
</tr>
<tr>
<td>Number of Consultants</td>
</tr>
<tr>
<td>No Show patients</td>
</tr>
<tr>
<td>Number of Overbooked Appointments</td>
</tr>
<tr>
<td>Clinic Utilization</td>
</tr>
</tbody>
</table>

This study has chosen post-implementation to clarify the idea before real implantation. This will reduce the cost and the effort by assuming percentage of no-shows patients who will respond to the confirmation service. Figure 4.5 shows if 10% of patients responded to the system, then four available slots can be replaced with overbooked appointments. If 50% of patients responded, that means all overbooked patients will have a booked appointment on that day. If
100% of patients send a cancellation response before the appointment date, a total of 20 extra slots will be available. These available slots can be utilized for the new referral appointment daily requests.

![Figure 6-5 Probability of appointment cancellation responses and resulting available slots](image)

6.3.2 Ticket Numbering Problem in Queuing Software

In this section, the study will focus on proposing solution for the second problem that affected the patient flow. This problem affects the patient experience because the ticket order number is not reflecting the real order. This section will give more details about the problem with its solution.

6.3.2.1 Proposed Solution for Ticket Numbering: Requirement Phase

This study addressed this problem during the interviews with staff and patients. The patients came to the reception area complaining that her/his order should come first according to the ticket queue number. The receptionist usually replied that the ticket number was not according to the queue, it was based on the appointment time. By referring to the reception dashboard, the researcher found out the ticket numbering problems.

In Patient check-in stage, the queuing system generates a ticket number to call the patient from waiting area using a television screen that displays the patient number. The number identifies the patient beside her/his (MRN) Medical Record Number.
The ticket number is generated in serial order regardless of the appointment time, but calling the patient comes according to appointment time which makes the patients confused about when their turns come. The patient assumes that if her/his number is lower than her\his neighbor, then he has right to be the first served. This behavior is called patient experience or user experience in human computer interaction fields.

The overbooked patients come early and take a ticket number; s/he has the same assumption of ticketing order number. However, unfortunately s/he is waits a long time until all booked patients are served first.

As can be seen in the Figure 4.6, that the patient with Q103 has an appointment at 11:14 AM while the patient with Q218 has an appointment at 10:16 AM. Based on patient experience, the patient assumes that the turn of the patient holding Q103 should come before the one with Q218. But this is not reality, the call patients according to the appointment time.

![Figure 6-6 Ticket Number Generation: Queue Problem](image)

This ticketing order has been built based on the outpatient management requirement. The idea is to hide the patient order. The management thinks that if they give real queue ticket number, then the patient will be complaining for failure to be served on time. Naturally, the patient assumes that the ticket number is according to the queue number not a random order. Another
concern is with late patient, the outpatient management deal with late patient as overbooked patient, their priority becomes lower than the on time coming patient.

6.3.2.2 Proposed Solution for Ticket Numbering: Design Phase

Using a serial number generated according to the appointment time regardless of arrival time could probably provide a reasonable solution to the issue and give the overbooked or walk-in a priority in case there is an empty slot. If the patient is late, the system will automatically consider the patient as an overbooked or walk-in patient. Since the percentage of overbook around 30% of the overall appointments. The same percentage can be used to reduce the patient waiting time. By giving the right number, this helps to avoid confusing the patients and also reduce the percentage of overbooked waiting time.

6.3.2.3 Proposed Solution for Ticket Numbering: Post Implementation Phase

The difference between this solution and the confirmation solution that was mentioned earlier is that the confirmation takes place 48 hours before the appointment time, while this proposed solution is for the patients who have actually arrived at the clinic. Figure 4.7 shows the queuing system generating the numbers according to the appointment time by giving the priority to booked patients. In case of late or no show patients, the slot will be automatically used for overbooked or walk-in patients. For example, if patient Q004 does not show up, so the first arrival patient A001 in the waiting list will be the next patient to be called. Q009 is late so, A002 will be the second patient. The order of waiting list is according to arrival time. The Q009 will be given another number A006 because he is late and he will be in the waiting list waiting for any empty slot or after serving the entire scheduled patients.
6.3.3 Doctor Clinic Reporting Problem

6.3.3.1 Proposed Solution for Doctor Clinic Reporting: Requirement Phase

Consultant reporting time to the clinic is the third factor that has a direct impact on the patient waiting time. A major key of improving the quality of healthcare is having medical staff operate their clinics on time. Most of organization use reporting time attendance software to record the attendance of their staff. This gives an indicator of their efficient performance linked with staff annual performance evaluation system. KSA-hospital applies a software called On Call Schedule (OCS) for the medical staff. It is a 24/7 service, so the medical staff like nurses, doctors, technicians, pharmacists, and radiologists are included in the on call schedule at different levels for the month. This schedule is uploaded in the hospital intranet page. Verifying the attendance of the medical staff linked with oncall system has not been implemented. This important metrics has not been measured yet.

The consultant’s attendance time has a direct impact on patient waiting time,
especially for the first appointments both in the morning and the afternoon session's time. Figure 4.8 shows the average consultant late time in minutes for two months divided by weeks. As a sample of 5606 visits in 2 months for two sessions: the morning session starts at 8:30 AM and ends at 12:00 PM and the afternoon session starts at 13:00 PM and ends at 4:30 PM.

![Average Consultant Late Time Chart](image1)

**Figure 6-8 Average Doctor Late time in minutes for (January 2015 and February 2015)**

The average late reporting of consultant to clinics is between 20 minutes up to 49 minutes, leading to dissatisfaction of the patients who wait for a long time after vital signs checking. Figure 4.9 explains the cost effect of doctor late sign-in time.

![Cost Effect Chart](image2)

**Figure 6-9 Total cost due to consultant late reporting time in Saudi Riyal (SR)**
The impact of ignoring the Time Attendance Software to monitor the consultant attendance has resulted in losses for the KSA-hospital reaching between 26,879 SR up to 65,843 SR per week. This calculation is covers 378 consultant and the average salary of the consultant is 3.57 Saudi Riyals per minute.

6.3.3.2 Proposed Solution for Doctor Clinic Reporting Problem: Design Phase

For better clinic service utilization, monitoring doctor time attendance is a crucial factor to control the delay of clinic starting and ending time. According the outpatient clinics policy, clinics should start at 8:30 AM while other departments in KSA-Hospital start at 7:30. The outpatient administration provides the doctor one hour starting work time to visit their inpatients, write the pending reports and reply to their emails before actual clinic starting time.

As a part of the hiring process, the hospital provides an identification card to each employee. This card is used for opening doors, which are secured by electronic access control software. Access control software is software that contains a reader next to the door. The door remains closed until someone has an access to open it. Sometimes patients disturb doctors during the clinic time, the door is accessed by concerned staff only.

By implementing the idea of card access, the software can detect the doctor sign-in by reading the log of Access Control Software. The Access Control Software will send the first log of the doctor to the Time Attendance Software and human resource software through a web service as shown in Figure 4.10.
Figure 6-10 Time attendance integrated with Access Control Software

Figure 4.11 illustrates the current status of the clinic starting time. Some consultants come late to clinic and the red color shows that the first appointment sometimes start at 9:00 AM, and this delay affects all the appointments in that session and shifts them. The clinic starts mostly at 9:00 a.m. instead of 8:30 and the first, second appointments are affected and are late as shown in red slots or will be late to overlap third and fourth appointments as shown in yellow color. The fifth and sixth appointments remain in green since the time taken for this sample was 9:00 a.m. The proposed solution suggests that the clinic should start on time and it reflects the percentage of improvement if this solution is applied.
6.3.3.3 Proposed Solution for Doctor Clinic Reporting Problem: Post implementation Phase

A Sample of random 2000 visits has been studied to see by simulation the impact of doctor reporting time to clinic. The waiting time that will be affected is the clinic waiting time. Therefore, according to the current data, the average waiting time is 45 minutes and if the proposed time attendance is implemented, the ratio will be dropped down to 36 minutes i.e. 20% improvement.

Simulation Result for current clinic average waiting time is shown in Figure 4.12. The flow of patient in the clinic where the circles represent the flow steps and the arrows are used for calculation.
Figure 13 shows the simulation result for proposed solution and the impact on clinic average waiting time.

![Figure 6-13 Screenshot from the simulation after improving doctor attendance time](image)

By assuming that doctors start on time and run the simulation with same data, the overall waiting time drops down to 20% (3.1 min as an average for each session). The consultant doctor attendance time is not the only time affecting waiting time. Some effect is not clear, particularly because of late or early arrival of patients.

6.3.4 Early Coming Patient Problem

In this section, the study will focus on patient behavior. Most of patients come before the session start. The study will explain the impact, the reason and solution.

6.3.4.1 Proposed Solution for Early Coming Patient: Requirement Phase

Another problem related to ticket queue number problem is the early coming patient. Because the queue number is given according to the arrival time regardless of appointment time, the patient comes very early to the clinic. Figure 4.14 shows that the number of check-in patients versus expected or booked patients. This makes the waiting time longer because the patients assume that the working time start from check-in time to discharge time. This problem occurs because of the conflict between the outpatient management and medical staff management inside the clinic.
Figure 6-14 early coming patients for one day

The clinic does not expect any patients between 6:30 and 8:00, while the patients who arrive before 8:00 a.m. average 22 patients. The clinic official time starts at 8:30 a.m., and the number of patients waiting reaches 62. The clinics expect only 13 patients at this time and the clinic has seven consultants in the morning session.

The service after patient check-in is managed by doctors and nurses. Inside the clinic, the patient turn is according to the patient arrival time; First In, First Served (FIFS) not First Appointment, First Served (FAFS). The main cause of this issue is the misunderstanding and lack of collaboration between the outpatients department and the medical department.

The consultant prefers to see the patients according to their arrival time. Some consultants say that some of patients are very sick and they need wheelchair services, so consultants try their best to reduce the patient waiting time. Outpatient Management and Clinic Management have the same goal, but there is no collaboration between the two departments, each tries to solve the issue from its side. These conflicts are known by the patients. In the appointment slip, there is an instruction “Please come 30 minutes before your appointment time”. On the other hand, the nurse gives patients verbal instruction to come
early to the clinic because their service slogan is "first come, first served".

One of the biggest challenges for KSA-hospital is the early coming patients and as we explained before, the patients come early because of their experience in their previous appointments. If they come first, they will be served first and the people understand reality more than written rules.

It is very difficult to calculate the service waiting time because of this issue. Surprisingly enough, some patients come and finish before their appointment time starts. This issue is also affected by the patient no show, because the clinic has to wait for the patient until the end of the session or the end of the day if the clinic has two sessions in the same day. Most of the consultants do not know how many patients they see every day, because there is discrepancy between their work schedule and the reality. When the booking schedule is fully booked, some consultants give the patient a small paper with a stamp to come at the time that he the patient chooses for himself.

**6.3.4.2 Proposed Solution for Early Coming Patient: Design Phase**

Figures 4.15 and 4.16 show the result of 2000 sample visits made. Simulation is used to see the impact of patient arrival time on vital waiting time. The waiting time affected is the vital waiting time. So according to the current data, the average waiting time is 21 minutes. However, if we apply the clinic arrival control system, the number will go down to 10 minutes i.e. 52.3% improvement. In order to solve the current issue, in addition to the instruction on the appointment slip, the Queue Software should not accept any patient 30 minutes before appointment time. This function is called clinic arrival control, and the software should reflect the policy and it should not be different.
6.3.4.3 Proposed Solution for Early Coming Patient: Post Implementation Phase

Simulation Result for proposed solution, the impact on vital average waiting time.

If the Time Attendance and Clinic Arrival Control are implemented and integrated with Queuing Human Resource Systems, the clinic waiting time and the vital waiting time will be cut down as shown in the Table 4.3.
Table 6-3 The impact of time attendance and clinic arrival control on overall waiting time

<table>
<thead>
<tr>
<th>Waiting Time Type</th>
<th>Current Process</th>
<th>Proposed Solution (Simulation)</th>
<th>% of Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital Signs Waiting Time</td>
<td>21 minutes</td>
<td>10 minutes</td>
<td>53.3 % of VWT</td>
</tr>
<tr>
<td>Clinic Waiting Time</td>
<td>45 minutes</td>
<td>36 minutes</td>
<td>20% of CWT</td>
</tr>
<tr>
<td>Overall Waiting Time</td>
<td>66 minutes</td>
<td>46 minutes</td>
<td>30.3% of OWT</td>
</tr>
</tbody>
</table>

6.3.5 Patient Distribution list

The last factor affecting patient waiting time is missing data requirements. The clinic booking uses one consultant's name, but the consultant has a team called assistant consultants, so the study will figure out the missing requirements affecting clinic service time which in turn affects the clinic waiting time.

6.3.5.1 Patient Distribution list Requirement Phase

Each consultant has one assistant consultant per 10 patients. For example, if the consultant has 35 patients he will have two assistant consultants helping him in his clinic. The assistant consultant is part of a team helping the consultant to examine the patient. The current booking system schedules all patients under one consultant. That means if a consultant has a team of assistants, the assistant name is not reflected in the clinic schedule. So, if the consultant has one more assistant, then he can accept more patients but in the booking software the time is not quite reliable.

In clinic management, there are two types of clinic flow: the first one is when the patient is assigned to one consultant as shown in Figure 4.17, the patient is
examined by that consultant.

![Diagram](image)

**Figure 6-17** the flow when patient is assigned to one consultant

The second type of flow is when the patient is assigned to a team. In this case and as Figure 4.18 shows the patient can be seen by the consultant or by an assistant.

![Diagram](image)

**Figure 6-18** : Patient flow when the patient is assigned to consultant team

In the current queue, the system assumes that the patient will be seen by a specific consultant. The consultant team information is not saved in the Outpatient Booking Software, so the software cannot measure the assistant
consultant performance.

As a current procedure, the consultant checks manually all patients under the clinic; distribute them manually according to patient priority level. Later on, the assistant consultant uses the consultant queue system account in different clinic rooms. This information is not shared with the patients. The patient does not know who will examine him and which room he is supposed to go to. Thus, the nurse guides each patient to the concerned clinic room.

6.3.5.2 Patient Distribution List Design Phase

Figure 4.19 and 4.20 show the distribution list idea of one of the consultants in the clinic. It is a new screen that has the assistant consultant account and the clinic rooms controlled by the consultant. For each session, the consultant allocates the patient to the room and assistant or he can use equal distribution button to distribute the patient equally. This idea helps the consultant to focus on his work and the nurses will not waste their time to guide the patient to the assistant consultant's room.

![Figure 6-19 Patient distribution list in Consultant screen](image-url)
6.3.5.3 Patient Distribution List Implementation Phase

In the implantation phase, the simulation will be used to see the impact of waiting time in clinic by using the patient distribution list. In the Table 4.4, the average waiting time is changed when a new room is added and counted, assuming the time from current observation and the result according to expected number of rooms for 100 patients. By assuming the clinic without distribution list, it takes 18 minutes for each patient. The time needed for the patient to arrive at the clinic is 4 minutes. With distribution list, the clinic service time is 15 minutes and the time needed for the patient to arrive at the clinic is 2 minutes. Table 4.4 shows that using a distribution list improves clinic service time.

Table 4.4: The Clinic waiting time before and after applying the clinic distribution list

<table>
<thead>
<tr>
<th>Number of Clinics</th>
<th>Average Clinic Waiting time Without Distribution list</th>
<th>Average Clinic Waiting time With Distribution list</th>
<th>% of Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Clinics</td>
<td>196 minutes</td>
<td>134 minutes</td>
<td>31.63 %</td>
</tr>
<tr>
<td>three Clinics</td>
<td>64 minutes</td>
<td>41.6 minutes</td>
<td>35.00 %</td>
</tr>
<tr>
<td>four Clinics</td>
<td>24 minutes</td>
<td>11 minutes</td>
<td>54.17 %</td>
</tr>
<tr>
<td>five Clinics</td>
<td>9 minutes</td>
<td>6.2 minutes</td>
<td>31.11 %</td>
</tr>
</tbody>
</table>
Based on simulation results that there is no difference between one or two clinics with or without distribution list using initial assumption because the small of number of rooms is and it is also easy for the consultant to manage one assistant. However, if the doctor has more than two rooms, it will be difficult for him to manage without software. So we can see the improvement in Table 4.4 when the distribution list is used for more than two rooms. Beside the improvement in the clinic service time, the outpatient clinics management can see the performance of the doctor and his assistant separately, so it will help them for better decisions in the future.
CHAPTER FIVE: CONCLUSION
7.1 Introduction

This chapter provides a conclusion to this study and answers the main research question, presented in the introductory chapter.

7.2 Research Conclusion

In this study, the main point is the patient flow from software engineering point of view based on the satisfaction level of patient as a measurement that cannot be measured directly. So, by identifying the services in outpatient clinic, the researcher relies on waiting time as a metric that can be collected from the systems to identify the level of patient flow problem in the Saudi Hospitals.

The result of this research shows a scientific improvement in patient flow in the outpatient clinic. The study discusses four major issues and puts forward one recommendation.

1. The first issue is pertaining to the type of appointment. The KSA-Hospital tried to solve the no-show problem by applying a new type of appointment called overbooked appointment. This type of appointment did not include the appointment time. As impact, the KSA-Hospital could not measure the waiting time since it was not available. Applying confirmation message solution to the overbooked appointment problem will reduce the patient no-show problem. This solution also helps to have a real measurement of waiting time because as we explained before that the outpatient clinic service is based on arrival time not on appointment time. This solution can also help to utilize the unused appointment slots to be used for or to reduce the long time appointment period.

2. The second issue is patient line order number generated by the Patients Queuing Software. The number is generated according to newly-registered
arrival time not appointment time. The software calls the patients based on the appointment time regardless of queue order number. This problem confuses the patients. By giving order number based on appointment time, this helps to harmonize between software process and the patient experience. This improvement helps to manage the patients flow according to a real queue and then collect the actual time for the clinic service.

3. The third and fourth issues are early coming patients and late doctor report time. 30.3% improvement of the overall waiting time if the clinic arrival controls and time attendance control are integrated with outpatient software and queuing software.

4. The fifth issue is concerned with missing requirements like the distribution patient list and dashboard. The distribution patient list can help the consultant to manage his assistants during the clinic session. He can also monitor their performance beside his main job which is patient examination. The simulation shows an improvement in clinic time if we use the distribution list. The time is improved by 54.4 % average maximum.

7.3 Research Recommendations

This section will list some of the recommendations from software point of view and business point of view that affect patients' flow which need to be studied and applied in future.

7.3.1 Outpatient Management Software

From OMS point of view there are some recommendation that helps in improving patient flow and decrease the patient waiting time includes:

1. Integration between clinical software and single sign implementation in order to effectively automate the process. It is very important to use single sign because it will help to reduce the time of opening different software.
2. Use mobile for auto-check since KSA-hospital is a huge organization and the patient can follow up his order from anywhere.

3. Dashboard in queuing management system. There are many types of users using the software to serve patients on time. The receptionist monitors the overall clinic, registers the uneducated and old patients by using the reception queuing desktop application.

7.3.2 Recommendations in Business Area

From business point of view, there are some recommendation that helps in improving patient flow and decrease the patient waiting time includes:

1. The no-show appointment creates a great barrier for the automation of the software. There is a need to develop a clear policy by the hospital administration regarding the no-show problem. Solve the no-show problem by applying a policy that closes the service if the patient does not show for three times.
2. Cooperation between clinical and outpatient management to reduce the conflict and achieve patient satisfaction.
3. There is a need to develop a service based on patient satisfaction.
4. Rearrange the clinic layout according to the patient flow.
5. Create a committee reporting to high management and working on reducing the clinic service time.
6. Hire a person who is responsible for guiding patients to their clinic if they are lost.
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