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Service Performance Improvement Model: The Case of Teklehaymanot General Hospital

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Abstract

In service sector, there are challenges in keeping an optimum balance between customers' demand and availability of resources. This problem is going to be more intense in the health sector due to the fact that both arrival and service times are random. Therefore, designing the service environment by keeping the optimum balance between customers' demand and available resources is becoming a series problem in Teklehaymanot General Hospital. This paper tries to develop a model that investigates the performances of Teklehaymanot General Hospital and determines the optimum number of specialist doctors based on their respective workload. To address this objective, the study develops a model using Arena Simulation Software that considers the real working environment and scenario of Teklehaymanot General Hospital. For the purpose of this research, three years' secondary data that include the type of services and number of specialized doctors under each service channel are collected from the hospital records and fitted to the model. The findings of the study show that there are unbalanced distributions on the daily workload among specialist doctors and extended long waiting time of patients in Teklehaymanot General Hospital. It reveals that specialist doctors who are working in pre-breast center, Hematology oncology imaging, neurology, obstetrics & gynecology, ophthalmology, pulmonology, urgent care, urology and women's imaging are relatively overloaded, whereas those who are working in ENT Allergy Audiology, gastroenterology, Nuclear Medicine, orthopedics, physical therapy, and surgery are relatively underloaded. Moreover, from the scenario analysis, the result shows that additional specialized doctors in the fifteen areas are required so as to reduce the waiting time of patients by 54.41%. Therefore, the hospital is recommended to have a balanced workload distribution among specialist doctors and increase the number of specialist doctors by one or two in the fifteen service areas.

Keywords: Arena model, Hospital, Scheduling, Specialized doctor, Service performances.

1. Introduction

Health is becoming a growing concern from time to time in Ethiopia. To this effect, more and more number of hospitals and health care centers are being built and opened in the country. Reports of WHO (2010), CSA (2013), and Ministry of Health (2010) showed that there is 20% to 31.5% growth in the health sector in Addis Ababa city and 17.4% to 46% growth in the overall health care centers in Ethiopia. Despite this encouraging effort and increasing number of health care centers and hospitals, however, the health care services in Ethiopia are still among the least developed ones in terms of quality and responsiveness as compared to the sub-Saharan Africa; still, it is not effectively handling the ever-increasing demand in the country (WHO, 2010).

Many donors and partners have been supporting the Ethiopian Ministry of Health to keep pace with the growing population in the country. Among many others, the most notable evidence is that the first national Health Information system in Addis Ababa has beend eveloped by Tulane University. Similar efforts were also made by WHO (2010) and MoH (2010). However, the shortage and in-balance of specialist doctors are still becoming a lingering challenge for most private and government hospitals in the country. This challenge is realized and reported by WHO by the year 2010 (WHO, 2010).

From its survey, WHO reported that the proportion of doctors to population in Ethiopia is 1: 36,500, which is far behind as compared to the developed nations. In addition to this, designing an optimum balance between customers' demand and available resources in the hospitals is one of the main impediments to the service performances of Hospitals in Ethiopia.

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This problem has subsequently resulted in long patient waiting time in the health care centers and hospitals in Ethiopia. The amount of time that a patient waits to receive service in healthcare centers is one factor which affects the performances of the health care services. Patient satisfaction is increasingly becoming more important parameter in the assessment of quality of health care, taking into account the constantly increasing number of private healthcare centers in Ethiopia.

Teklehaymanot Generalized Hospital is one of the highly recognized and experienced health care institutions in Addis Ababa, Ethiopia. It has 21 specialized departments and nine test and examination laboratories. However, the hospital has a major challenge of determining the optimum number of specialized doctors that can meet the stochastic customer demand even for specialized service. Minimizing the long queue at some departments and reducing excessive idleness on the other departments have become a challenging work in this hospital. Consequently, these issues have resulted in low service performance and unsatisfied customers, whereas the international practice showed that healthcare facility performance can be best assessed by measuring the level of customers'/patients' satisfaction (Merkouris et al., 2013).

The purpose of this paper is, therefore, to develop performance improvement model that improves the system utilization and efficiency while minimizing the waiting time of patients in Teklehaymanot Generalized Hospital.

2. Literature Review

Many scholars agree that the current health concern of city dwellers is increasing from time to time. The reason behind this varies from scholars to scholars. Some of them are, if not all of them, stated that the change in the environmental condition, consumption of artificially synthesized foods, and excessive medicines are some of the reasons (Barata et al., 2011; WHO, 2010),whereas others argued that, in the recent development due to the improvement ofpeople'sbuying capacity and health awareness, the demand of the health services is increasing. They argued that these make people rush to hospitals and health facilities (WHO, 2010). The results of these concerns are manifested in the improvements of quality-of-life indicators. For example, the life expectancy of Ethiopian is increasing by 3% every year (WHO, 2010).

From the investment perspective, in recent years, there have been many projects related to health. These projects were owned by government, local and foreign private investors and non-for-profit organizations. For instance, the Russian, the Chinese, the Korean, and the Indian nationals are some of them who are currently opening and running different health institutions in Ethiopia. There are two critical factors behind these motives. These are increasing demand on the local market and government supports the health sector in the country, according to Ministry of Health (2010). The requirement of health insurance services for the increasing number of international travelers and the new health insurance policy enforced by the Ethiopian government creates health care service demand which subsequently creates more challenge to the unprepared health sector more than ever (Ministry of Health, 2010).

As stated by Sam and Alex (2014) and Umar et al. (2011), specifically in developing countries, the waiting time for patients in order to get services is relatively very long and frustrating. Waiting time for a patient as defined by Globerman (2013) is the length of time when the patient enters the outpatient clinic to the time that the patient actually leaves the Out Patient Department (OPD). Whether it is a time used for registration of patient, doctor's appointment, emergency room treatment, laboratory, procedures, receiving the results of various tests, long waiting happens just to everyone at every stage of the service channels. Most waiting time is due to unbalanced work load distribution among medical workers or few numbers of doctors in some service areas. All these will have an effect on the performances of the overall systems of the health care centers.

Furthermore, recent research findings show that the workload distribution may take into account all possible factors affecting the professionals' workload. Nevertheless, the number of work interruptions, the patient turnover rate, and the number of mandatory registrations are the most important factors in the workload distribution. The complex and immediate need of today's patient and the sensitive nature of the service demands a sufficient number of workers per ward to give a prompt service so as to avoid adverse outcomes. At the same time, workload is increasing due to fewer human resources (Dries et al., 2012; Jennings, 2011). Other studies have tried to implement workload management system in the health care service. For example, Pretto et al. (2009) collected data of the administrative record for a series of two years, computed the workload of 200 patients, and improved the work load by 2.2%, which is insignificant.

Further, in Catalonia, Spain, longitudinal study was carried out on 72 primary health care teams with a one-year follow-up of 1,068 home care patients over 64 years old. Their findings show that there is a positive correlation of workload with variables related to disease severity and the negative correlation with variables related to cognitive impairment (Joan et al., 2011).

However, the findings of Carrara et al. (2016) had different results, such that the mortality, morbidity, and nursing workload are not different between the obese and non-obese groups. In some centers, the workload distribution is far from optimal due to the fact that nearly one third of the working time is occupied by administrative task, which would have been invested in health care (Francois et al., 2014).

Various studies, regarding reasonable work load and work hours for physicians, were undertaken (Hsues-Fen et al., 2010, Rodriguez et al, 2014). For example, the study conducted in Taiwan showed that work hours among departments differed significantly. As evidence, it was shown that physicians in surgical departments spend the longest hours in clinical work (Hsuesh-Fen et al, 2010). The same study emphasizes that work hours do not definitely represent work intensity, and to define the workload by working hours may be in appropriate for some departments.

According to (Globerman, 2013; Manuela et al., 2009; Hsuesh-Fen et al, 2010), and by considering various conditions of patients in the system, the waiting time of patients in healthcare centers is categorized as follows:

- Retrospectively: the actual measured waiting time for those who received care
- Prospectively: the expected waiting time for those who need care
- Cross-sectional: the elapsed waiting time of those currently waiting for care as of a specific date.

Therefore, it is necessary to clearly identify and draw a reasonable assumption on the type of waiting times when performance improvement models are designed.

3. Assumptions onthe Model Development

In carrying out this study, the following three main assumptions were taken into consideration.

First, the hospital has no plan to vary the number of departments, facilities and equipment in the near future. That means the number of specialists currently available in the existing system will also continue only in the existing facility and capacity.

Secondly, the difference in the mean service time and the capacity of the specialist doctors of similar specializations is considered to be negligible. For example, every gynecologist takes similar time to handle a similar case. Similarly, every cardiologist demands approximately equal time to treat similar cardiac patient. This assumption shall not underestimate that there are time variations in cases of the patient with different categories.

Thirdly, the number of front and back office workers, nurses, guards, laboratory and equipment technicians, and support staff will remain the same and their intervention and involvement will not affect the working time as well as the performances of the specialist doctors and general practitioner.

The work flow of the case company can be modeled as a multi-stage and multi-channel queue system after a series of direct observations on the actual duty of the staff in the hospital. The model considers the following points:

- Single Arrival Point: It is a point where a patient starts to join the system. This includes both new and already registered patients that are arriving and joining the system. The model does not include balking patients that do not join the queue and those who left the queue after waiting some time.
- If a patient is new, first he has to be registered, and then he will visit the General Practitioner (GP). But if the GP is busy, the patient will join the queue and wait until the GP will be free. Else, if a patient is already in the database or revisit patients, he will visit his specialized doctor based on its appointment, or the patient will join the queue if the specialized doctor is found to be busy at that moment.
- After visiting GP, the patient may be sent to the laboratories or referred to other specialized departments. Depending on the case, in some cases, the patient may also be recommended for further treatments.
- A patient that has completed all her/his services/examinations either will get prescription or future appointment or both, depending on the medical case.

3.1. Methodology

In this paper, the service processes of Teklehaymanot General Hospital are modeled as a multi-stage multi-channel queue system. Patient arrival times were collected at each point on the service channels. Moreover, three years' secondary data that include the type of services and number of specialized doctors are collected from the hospital records. In order to know the probability distribution of the collected data, the data are fitted to the Arena input analyzer. The findings of the Arena input analyzer are used as initial entity time for patients. In this paper, an entity is a patient that joins system whenever it needs a service. Since the hospital does not record its performance, a queue time and the mean system time for all of the entities are also recorded at each channel during the simulation run. The findings of the Arena input analyzer are presented in *Table 1*. The results show that most of the data collected follow Normal and Beta probability distributions. All the findings are statistically significant with p-values less than 0.05.

3.2. Arenamodel development

In the arena model, first events that are related to the specialists and patients are recorded as the simulation event list. The simulation event list is a means to keep track of different things that occur during a simulation (Kelton et al., 2002). An event is anything that occurs during the simulation run and can affect the state of the system. Typical events in a simple simulation include entity arrivals to the queue, the beginning of service times for entities, and the ending of service times for the entities. These events change the state of the system because they can increase or decrease the number of entities in the system or queue or change the state of the resources between idle and busy states.

The Arena model was developed according to the existing process and work-flow systems of Teklehaymanot General Hospital. It involves various Arena modules. For instance, the patient arrival was modeled using Create module as shown in *Figure 1*. The decide module was the next module used to identify the nature of patients. Some patients are new, while others are revisiting. A revisiting patient could be a patient who has already fixed appointment with the specialist doctor.

Table 1
Service time distributions by dervice type

Service	Distribution	Time	STDV
Breast Center (Pre-	normal	51.35	4.57
Cardiology	normal	17.57	2.88
ENT Allergy	normal	83.78	9.19
Endocrinology	normal	6.76	3.34
Family Practice	normal	79.73	8.99
Gastroenterology	normal	63.51	4.18
Hematology Oncology	normal	54.05	6.70
Internal Medicine	normal	33.78	5.69
Neurology	normal	63.51	5.18
Nuclear Medicine	beta	20.27	5.01
Obstetrics and	normal	72.97	7.65
Ophthalmology	normal	85.14	9.26
Orthopedics	normal	16.22	1.81
Pediatrics	normal	28.38	3.42
Physical Therapy	normal	68.92	4.45
Podiatry	normal	75.68	5.78
Pulmonology	normal	81.08	8.05
Surgery	normal	41.89	4.09
Urgent Care	normal	79.73	7.99
Urology	normal	8.11	2.41
women's Imaging	normal	51.35	6.57
Carding and	normal	45.95	5.30
General Practitioner	n ɔrmal	67.57	5.38
Prescription	beta	5.30	3.30
Immunization and	normal	7.56	5.36
Radiology	normal	24.15	7.23
X Ray	normal	12.43	4.12
Mammography	normal	13.78	5.19
Ultrasound	normal	23.24	5.16
CT Scan	normal	27.16	1.61
MRI	normal	22.70	7.64
Electro Cartography	normal	27.03	4.85
Other Lab Tests	normal	18.92	1.95

Those patients who are new to the hospital have to pass through the first registration process if their case is not an emergency. After the registration process, these patients have to leave the registration point and wait for a GP or specialist doctor. These doctors are the decision-makers to set which specialist the patient has to visit in its next step.

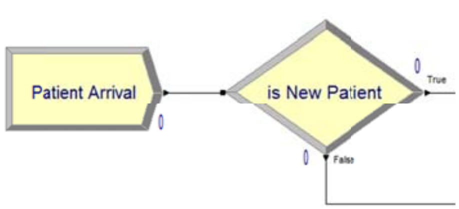

Fig. 1. Patient arrival using create module

The other modules used in the model are assign and record modules. Assign and record modules are used to store or modify statistical-related variables and records. These modules were used in most parts of the model as shown in the *Figures 2 and 3*. The time value and distribution function of the process module was set based on the data gathered from the case hospital, and the result was found from the arena input analyzer as reported in *Table 1*. The overall model is also presented in Figure 3. The simulation run was carried out based on this model using a Pentium core i3 processor Toshiba laptop. The model is simulated 100 number of replications and 1,000,000 hours of replication length.

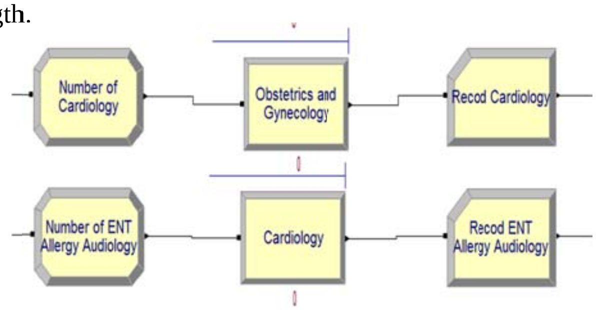

Fig. 2. Data storage using assign, process, and record modules

Table 2
Proportion of cases by the specialized

Cases by Specialization	%
Podiatry	8.15
Breast Center (pre-cancer)	6.43
ematology Oncology Imaging	6.42
Neurology	6.41
Obstetrics & Gynecology	6.41
Ophthalmology	6.40
Pulmonology	6.40
rgent Care	6.40
rology	6.39
women's Imaging	6.37
Cardiology	4.84
Endocrinology	4.84
Family Practice	4.84
Internal Medicine Laboratory	4.84
Pediatrics	4.84
ENT Allergy Audiology	1.67
astroenterology	1.67
Nuclear Medicine	1.67
Orthopedics	1.67
Physical Therapy	1.67
Surgery	1.67
Total	100%

4. Results and discussions

4.1 Patient and case distribution

As per the three years' secondary data of Teklehaymanot General Hospital, the findings of the result are presented in Table 2. It shows that the highest proportions of cases are related to podiatry, which accounts for 8.15% of the total proportions. This is relatively the most utilized case as compared to the other. Next to Podiatry, breast center (pre-cancer), Hematology Oncology Imaging, Neurology, Obstetrics & Gynecology, Ophthalmology, Pulmonology, urgent care, urology and women's imaging account for the second proportion in this study, whereas the last six cases, namely ENT Allergy Audiology, Gastroenterology, Nuclear Medicine, Orthopedics, Physical therapy, and surgery account for the least proportion out of the total cases.

4.2. Identify workload distribution

The simulation result of 21 specialists by department is presented in Table 3. The results show that there some specialists as overloaded and others asunder loaded. According to the findings, specialists that have utilized0.50 and above are considered to be relatively overloaded, whereas those specialists whose utilization is less than 0.2 are considered as relatively under loaded. The remaining are moderately utilized. To this effect, specialist departments, such as Breast Center (pre-Cancer), Hematology Oncology Imaging, Neurology, Obstetrics & Gynecology, Ophthalmology, Pulmonology, Urgent Care, Urology, and women's Imaging, with utilization of 0.58 are considered as relatively overloaded departments or specialists. However, ENT Allergy Audiology, Gastroenterology, Nuclear Medicine, Orthopedics, Physical Therapy and Surgery with utilization less than 0.50 are considered as relatively under loaded departments or specialists in Teklehaymanot General Hospital.

Table 3
Utilization and workload distribution

Specialist by Department	Utilization	WLPD
Breast Center (pre-cancer)	0.58	4.70
Cardiology	0.43	3.47
ENT Allergy Audiology	0.15	1.20
Endocrinology	0.43	3.47
Family Practice	0.43	3.47
Gastroenterology	0.15	1.20
Hematology Oncology Imaging	0.58	4.60
Internal Medicine Laboratory	0.43	3.47
Neurology	0.58	4.60
Nuclear Medicine	0.15	1.20
Obstetrics & Gynecology	0.58	4.85
Ophthalmology	0.58	4.60
Orthopedics	0.15	1.20
Pediatrics	0.43	3.47
Physical Therapy	0.15	1.20
Podiatry	0.72	4.73
Pulmonology	0.58	4.60
Surgery	0.15	1.20
Urgent Care	0.58	4.60
Urology	0.58	4.60
Women's Imaging	0.58	4.60

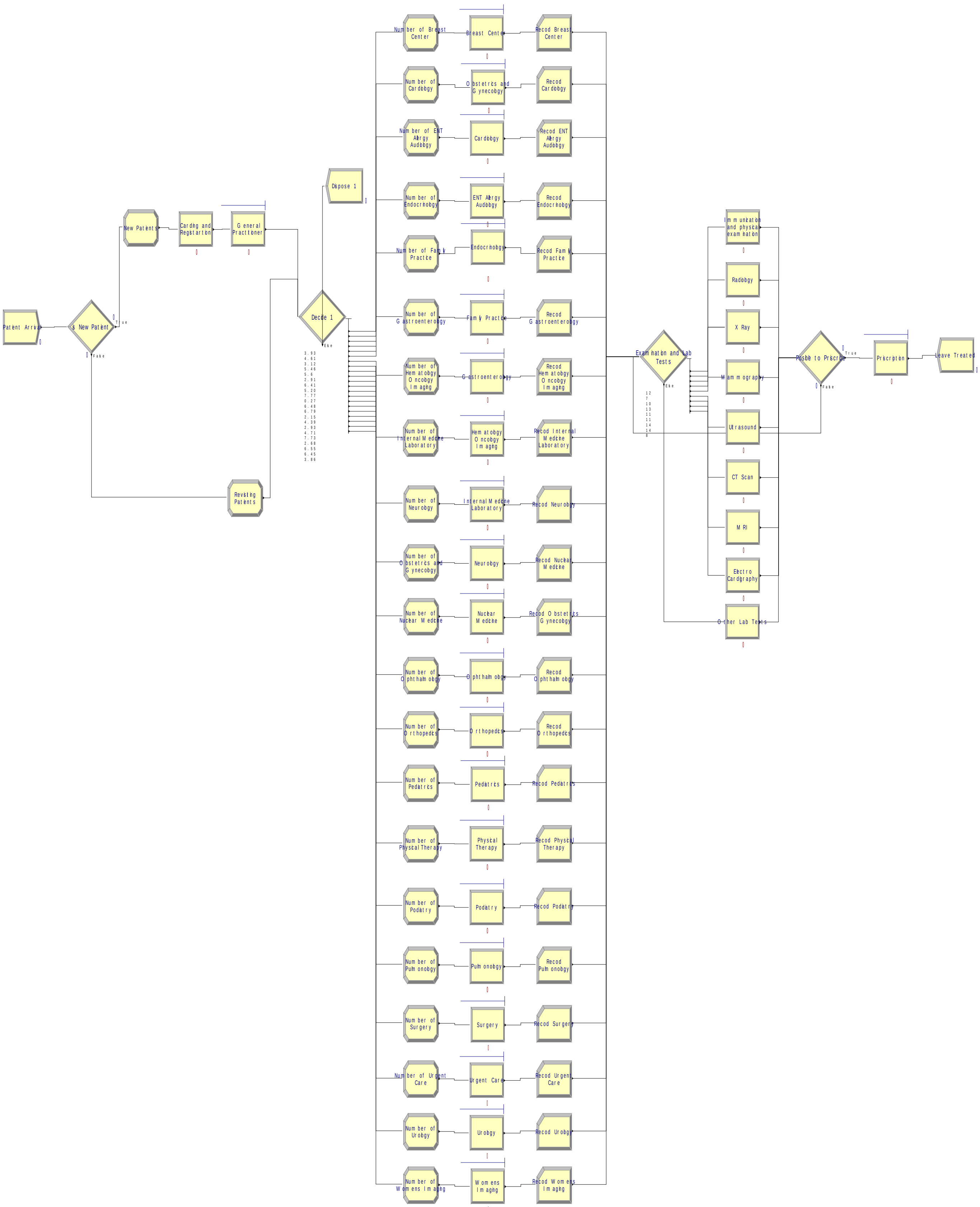

Fig.3. The overall operational system model (For readability, the details of the model are presented in the appendix A_1-A_3)

4.3. Results of scenario analysis

Based on the comparisons of different scenarios developed using Arena Process analyzer, it was observed that varying the number of GP and specialized doctors has an impact on the waiting time of the patients and the overall performances of the hospital. As shown in Figure 4, as the number of GPs increases, the waiting time of patients decreases. The minimum waiting time of patients decreases as the number of GPs increases. When the numbers of GP reach to 11, then the waiting time of patients remain constant afterwards. Furthermore, it is observed that when the number of GPs reaches eleven, then the patient's waiting time is reduced from 68 minutes down to 31 minutes which is a 54.41% reduction on the waiting time of patients.

Moreover, out of the total of 21 departments in Teklehaymanot General Hospital, it is observed that 15 of them, i.e., department Breast Center (pre-cancer), Cardiology, Endocrinology, Family Practice, Hematology Oncology Imaging, Internal Medicine Laboratory, Neurology, Obstetrics & gynecology, Ophthalmology, Pediatrics, Podiatry, Pulmonology, Urgent care, urology, and Women's Imaging, require to increase their number of specialized doctor(s) by one or two.

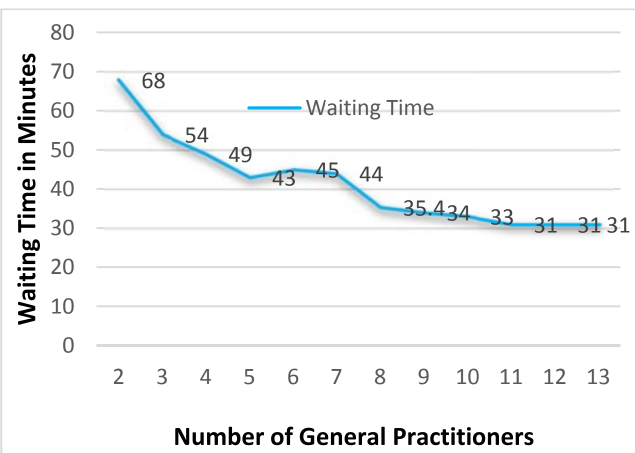

Fig.4. Waiting time vs. general practitioner

5. Conclusion and Recommendation

The purpose of this research is to improve the service performances of the Teklehaymanot General Hospital. Based on the major research findings from the simulation run, it can be concluded that the hospital is operating on unbalanced workload distribution and long patient waiting time in most of the service channels. It is found that the Podiatry is the most utilized department that serves the majority of the cases, and doctors in this department are relatively the most overloaded compared to doctors in ENT Allergy Audiology, gastroenterology, Nuclear Medicine, orthopedics, physical therapy and surgery. These findings are similar to those of (Joan et al., 2011; Francois et al., 2014, Hsuesh-Fen et al., 2010), such that the workload distribution varies among specialized doctors in various hospitals.

Table 4
The existing and proposed specialists

Doctors by Specialization	Current Number	Proposed Number
Breast Center (pre-cancer)	1	2
Cardiology	2	3
ENT Allergy Audiology	2	2
Endocrinology	2	3
Family Practice	2	3
Gastroenterology	2	2
Hematology Oncology Imaging	2	4
Internal Medicine Laboratory	2	3
Neurology	2	4
Nuclear Medicine	1	1
Obstetrics & Gynecology	2	4
Ophthalmology	2	4
Orthopedics	2	2
Pediatrics	2	3
Physical Therapy	2	2
Podiatry	1	3
Pulmonology	2	4
Surgery	2	2
Urgent Care	2	4
Urology	2	4
Women's Imaging	1	2

Further, based on the scenario analysis, the result shows that in the fifteen departments out of twenty one, the number of specialist doctors increases either by one or two. In addition to this, increasing the number of General Practitioners, in the hospital, up to 11 in most of these departments would reduce the patient's waiting time from 68 minutes to 31 minutes. Therefore, the hospital is recommended to implement the proposed number of doctors by department so as to improve its performances and reduce the waiting time of patients. Future research studies may address the performances of the hospital by including the administrative workers in the performance analysis.

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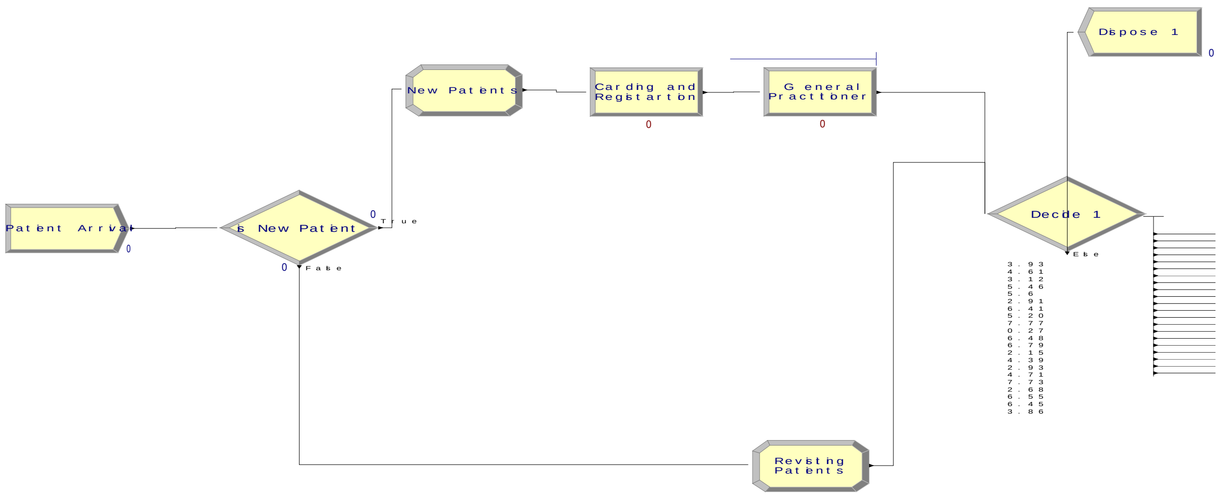
Appendix: A_1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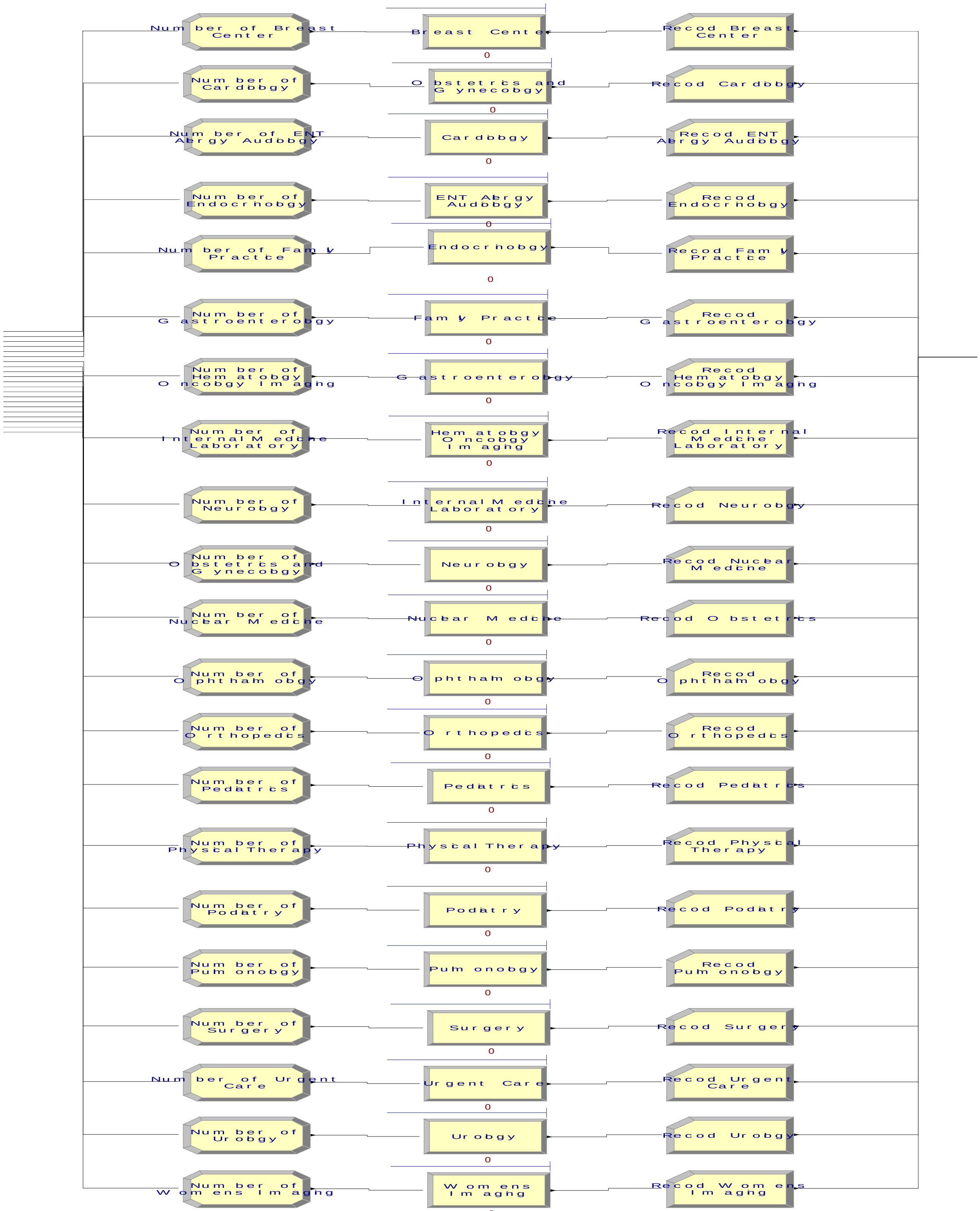
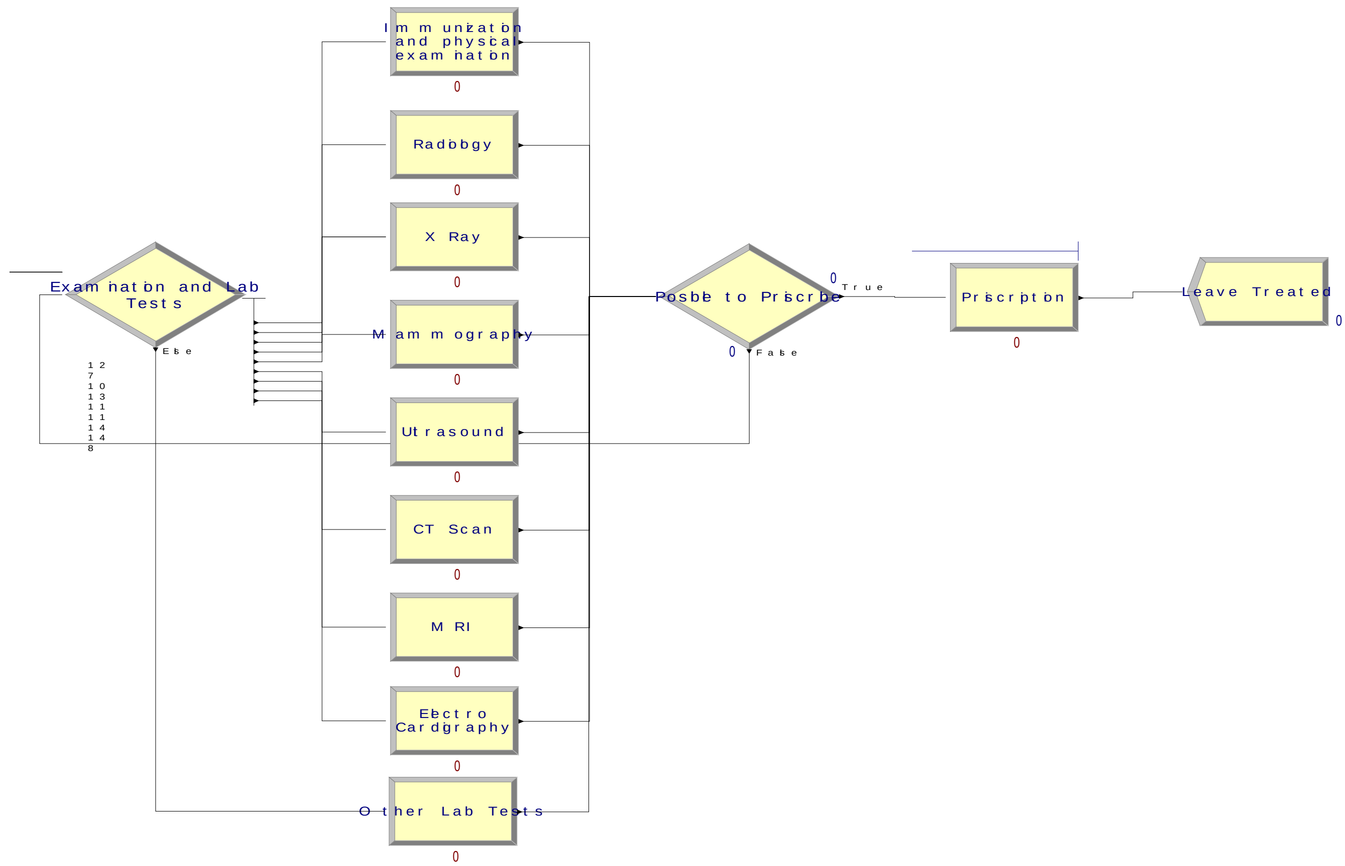
0
New Patients
Carding and Registration
0
General Practitioner
0
Patient Arrival
0
Is New Patient
0
True
0
False
Decide 1
Else
3.93
4.61
3.12
5.46
5.6
2.91
6.41
5.20
7.77
0.27
6.48
6.79
2.15
4.39
2.93
4.71
7.73
2.68
6.55
6.45
3.86
Revisiting Patients

Appendix: A_2



Appendix: A_3


Examination and Lab Tests
Else
Immunization and physical examination
Radiology
X Ray
Mammography
Ultrasound
CT Scan
MRI
Electro Cardiography
Other Lab Tests
Possible to Prescribe
True
False
Prescription
Leave Treated