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Reengineering Dental Hospital Information System Workflow Process: A case of the Obafemi Awolowo University Teaching Hospital Dental Clinic

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ABSTRACT

The existing workflow process that dental patients undergo in hospitals is riddled with repetitive steps. This has led to delays in dental service delivery. Thus, there is a dire need for a workflow process that will eliminate repeated procedures and reduce the waiting time of service delivery. This paper seeks to reengineer the workflow problem in a dental hospital with a view to reducing the problems encountered by dental patients. The time taken for each workflow process was obtained from the staff and patients in Obafemi Awolowo University Teaching Hospital Complex Dental Clinic through interviews and observation. The existing and proposed workflow process models were represented using Petri net as workflow net and designed using Unified Modelling Language (UML) tools. The models were simulated in MATLAB environment using Simulink. The performance of the proposed model was evaluated by benchmarking it with the existing model using patient throughput and waiting time as performance metrics. The result showed that the proposed model outperformed the existing model significantly by a reduction in patient waiting time by 36.8% as a result of the reduction in the number of processes from 14 to 8 processes, thereby leading to higher patient throughput of 0.2 patients/sec. It was concluded that the proposed model can be adopted by the Hospital management for more effective and efficient healthcare service delivery.

Keywords: Hospital Informatics, Workflow Management, Reengineering, Dental Clinic

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INTRODUCTION

The need for efficient healthcare service delivery cannot be overemphasized. According to Rodrigues (2010), healthcare is an organisation where reliable and timely information is a critical resource for the planning and monitoring of the provision of services at organizational, regional, national and international levels (Locatelli *et al*., 2012). At all the levels, day-to-day operation is mostly governed by a set of cooperative business processes, in which interactions between humans and information systems are involved. These make healthcare delivery to increasingly become a cooperative business that involves many individuals and organizations. In many developed and developing countries, healthcare organisations, such as hospitals, are under increasing pressure to improve efficiency and reduce costs (Helfert *et al*., 2005). Specifically, in a developing nation like Nigeria, the demand for hospital services is rapidly growing (Hongoro, 2004).

Hospitals are recently faced with the challenge of finding ways to improve the quality of healthcare, reduce costs and increase revenue (Emanuele and Koetter, 2007) thereby making process optimization, effectiveness and efficiency important factors in achieving operational goals. For example, the number of patients' visits to hospital increases on a daily basis while hospitals assets and infrastructures do not. Therefore, hospitals need to make better use of the limited assets and infrastructure and focus on quality of healthcare delivery. Also, Hospitals need support in controlling and monitoring healthcare workflow processes for patients (Dadam *et al*., 2000) so as to increase the interest in changing hospital informatics to support clinical processes in more direct work.

Hospital informatics comprise of various workflow process with varieties of interrelated tasks which need to be optimized (Kaiser, 2003). Dental informatics is the branch of hospital informatics that is focused on dentistry (Masic, 2012) which manages the information, communication and application of new technologies in clinical practice and research. Workflow management system is one of the suitable methods for improving hospital performance. This technology was accepted by hospitals as a way to improve their operational efficiency, achieve patients' safety and affect the quality of care delivered positively (Emanuele and Koetter, 2007).

Hospitals have adopted Information Technologies to support and optimize their workflow processes. The implementation of workflow systems in a hospital environment is difficult because many hospitals organize their work with a focus on departments and not on processes. The need for investigating the workflow design is due to some factors including introduction to the hospital of new healthcare information technologies and treatment methodologies; patient flow improvement in terms of cost and efficiency; initiates to ensure patient safety and; coordination of healthcare challenges.

The Dental clinic comprises of severaltreatment units which treat different sections of the oral cavity. Patients in dental hospitals are full of complaints arising from repeated activities that they have to undergo to get healthcare service delivery such as going repeatedly to a particular office (like cash office) to get a process (payment) done. This goes with queuing at each point and thereby increasing the time spent in the hospital. These repeated activities may lead to fatigue, frustration and delay of patients in the hospital.

Thus, in this paper, an attempt was made to reengineer the workflow process in the dental hospital with a view to reducing the problems encountered by dental patients thereby enhancing the provision of dental services in the hospital.

LITERATURE REVIEW

Related Works

Over the years, a lot of research has been carried out around the world on how to reengineer the workflow process in hospitals. Different techniques of Business Process Reengineering (BPR) have been employed in the reengineering of the patient flow process at hospitals to address the problem of inefficiencies leading to redundancy and lack of inoperability in the processes. For example, studies of the, Western Sydney area health service (Khandelwal and Lynch, 1999) and, Singapore hospital operating theatre (Kumar and Ozdamar, 2004; Kumar and Shim, 2010; Khan *et al*., 2008; Cassettari *et*

al., 2013) showed a drastic increase in efficiency with the utilization of the resources available in the hospital. It was also observed that the patients in the hospitals witnessed long waiting queues.

Thus, in a bid to managing the waiting times, inaccessible information, increase in costs of healthcare delivery and medical errors for patients and improving the workflow efficiency; Lee *et al*., (2010), Bakshi (2013), Dinesh *et al*., (2013) Mardiah and Basri (2013) Afrane and Appah (2014) proposed different BPR techniques to address these issues. It was noted that these studies provided a decrease in waiting time with an increase in resources. In light of the above, workflow technology has expanded substantially into the healthcare industry. It can be seen as a computer-assisted collection of activities related to a specific commitment, adding value to a product or service of the organization. This technology is a valuable tool for managing day-to-day operations as well as improving business processes over time. It helps to automate and improve business process which starts with the analysis of work processes in order to specify the people who do the work, information needed to carry it out, rules and regulations for how to carry it out, potential result and people who perform the next step in the process (Andrew, 2001). This technology was accepted by the hospitals as a way to improve their operational efficiency, achieve patients safety and affect the quality of care delivered positively (Emanuele and Koetter, 2007).The generic workflow of a dental clinic is as presented in Figure 1(Schwei *et al*., 2016).

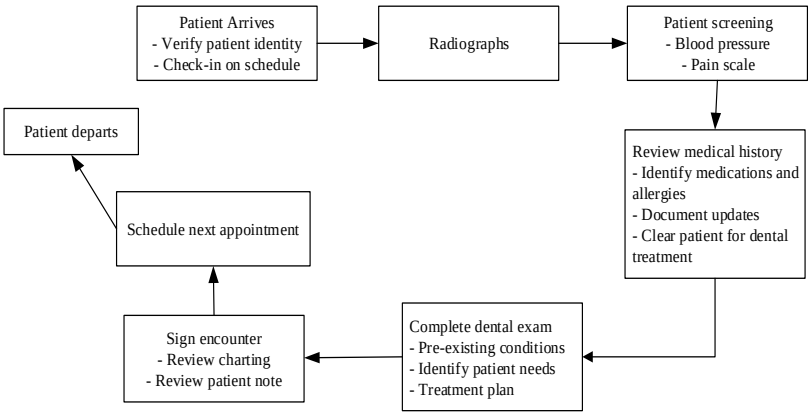

Figure 1: Workflow of Dental Clinic

Analysis of the Case Study

In this research, the workflow processes of a Nigerian hospital, Obafemi Awolowo University Teaching Hospital Complex Dental Clinic (OAUTHCDC), Ile-Ife, Osun State located inside Obafemi Awolowo University in Ile-Ife was used as a case study. Information was gathered using interviews and observation of the case study. Interviewees included the medical record officers, cashiers, nurses, radiographers, pharmacists, specialist/doctors at nine (9) different treatment units in the dental clinic each of which treats different sections of the oral cavity, namely: Oral and maxillofacial dentistry; Restorative dentistry; Endodontics dentistry; Pedodontics dentistry (Paedodontics); Orthodontics dentistry; Periodontics dentistry; Oral medicine dentistry; Oral pathology; and Community dentistry.

Existing Dental Hospital Information Workflow Process in OAUTHCDC

The present workflow procedure at Obafemi Awolowo University Teaching Hospital Complex Dental Clinic (OAUTHCDC) to achieve treatment as at the time of information gathering is as listed below:

i. A Patient goes to cash point for payment of registration/consultation.
ii. The Patient then takes the receipt to the record office to open the case note.
iii. The case note is taken to oral diagnosis for consultation.
iv. The Patient is referred to radiology for x-ray.
v. The Patient returns to cash point to pay for a specific radiograph.
vi. The Patient returns to radiology with the receipt for radiography.

vii. The Patient returns to oral diagnosis with x-ray result.
viii. The Patient is referred to the appropriate clinic for proper management.
ix. The Patient returns to the cash point to pay for specific management.
x. The Patient returns to the clinic with receipt for management.
xi. The Patient goes to the pharmacy with the prescription list.
xii. The Patient returns to the cash office to pay for drug(s).
xiii. The Patient returns to the pharmacy with the receipt for drug(s)

Based on the interviews conducted, the dental hospital information workflow process in OAUTHCDC ise depicted in Figure 2 with cloud symbols showing the area with the identified problems. The flowchart of the existing workflow is as shown in Figure 3. Also, the Petri net representation of the existing workflow process is as shown in Figure 4. The patient flow in the Petri net representation is either a new patient i.e. patient coming to the hospital for the first time who will follow *q0,q1,q3,q4,q3,q5,q6,q4,q6,q5,q7,q5,q7,q8,q9,q4,q9,q10* path or appointed patient i.e. patient coming for appointment who will follow the path *q0,q2,q3,q4,q3,q7,q8,q9,q4,q9,q10*.

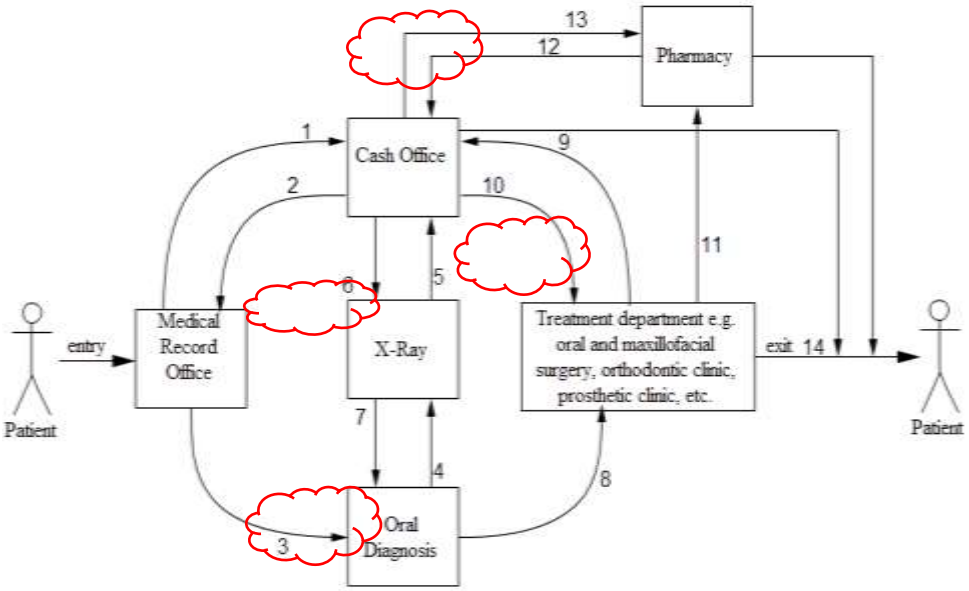

Figure 2: Conceptual View of Existing Manual Patient Flow in OAUTHCDC

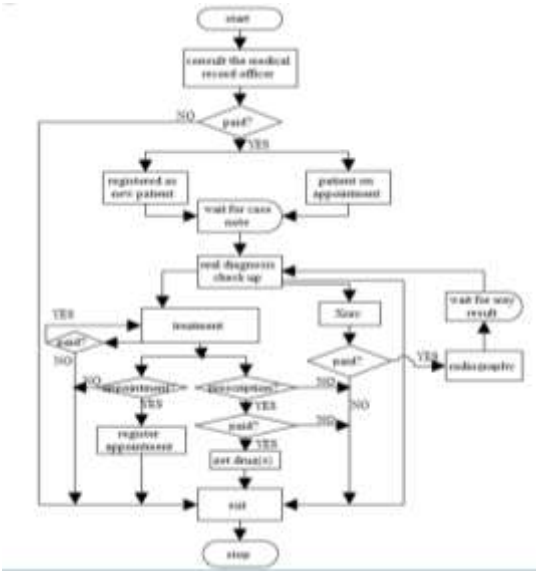

Figure 3: Flowchart of the Existing Workflow Process

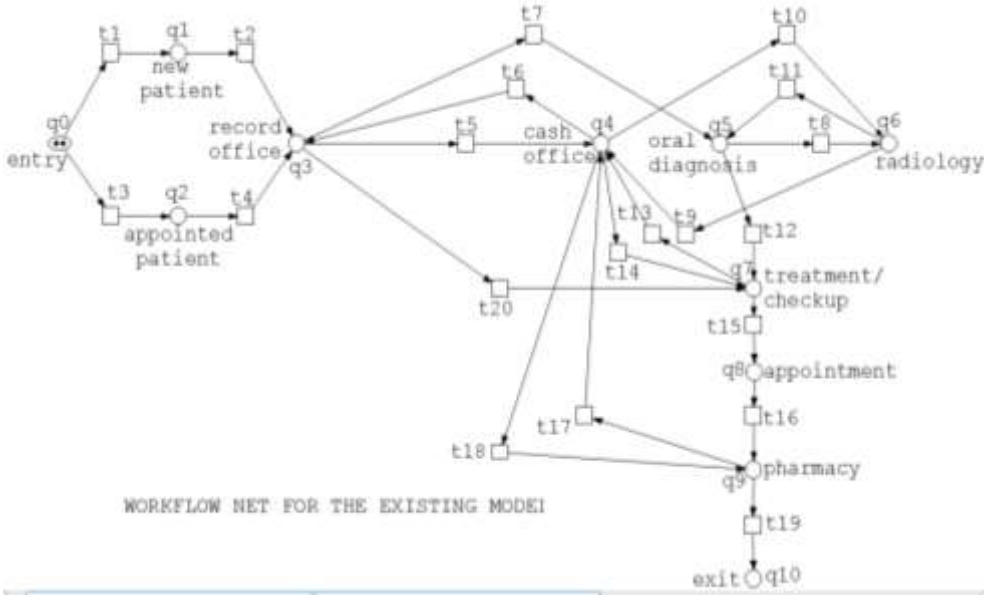

Figure 4: Petri net Representation of the Existing Workflow Process

Problems Identified with the Existing Workflow Process

The problems identified with the existing workflow process in OAUTHCDC are as follows:

i. The problem of the patient going back and forth in order to achieve success in a particular step or activity. For example, the movement of patient from oral diagnosis to X-ray (to get the price of the specified X-ray) to cash office (to pay) and back to X-ray (to tender evidence of payment) before the radiographer will attend to the patient and go back to oral diagnosis to get direction to the appropriate treatment unit. This same thing happens when the patient gets to the treatment unit. The patient is directed to go and pay at the cash office then come back for treatment.

ii. These movements of the patient causes delay in getting treatment as they are to wait so that they can be attended to in batches e.g. at the medical record office, or have to wait before their result will be ready as these tests are processed in batches e.g. radiography results. At times, the Patients have to queue at the cash office before they can make payment and patients that are registered with National Health Insurance Scheme have to go to Obafemi Awolowo University Teaching Hospital Complex (OAUTHC) located some distance from the hospital, to get clearance. All these also lead to a delay in treatment delivery to the patients.

iii. It was observed that most patients were given appointment in the morning making the clinic crowded and thereby leading to long waiting time.

RESEARCH METHODOLOGY

Business process reengineering is considered in this study because of the various stages it has which aids the understanding and improvement of the patient workflow process in OAUTHCDC. This procedure is based on the steps defined by Khodambashi (2013) in implementing reengineering.

Data Collection and Analysis

The research data that is, time taken for a process and the flow of patient within the hospital was gathered using interviews and observation from the case study. From the interviews, it was discovered that there was no existing document on the time it takes the patient to be done with a process thus making the interview and observation to be focused on the treatment/process time because this study is centred on time and patient movement in the hospital. The analysis of the data collected during the interview and observation is as shown in Table 1. The number of patients attended to was gathered from the nurses at each point because they kept a log book of all patients that visit the clinic for treatment or consultation.

From the logbook, the number of patients per day was taken for 1 month. The average was presented in Table 1. Patients' name was not reviewed during this process as it is not ethical in a hospital.

Table 1: Data Collection Analysis

Activity	Average Time Taken (Mins/Days(′)/Wks)	Average Number of Patients Per Day	Number of Chairs
Registration	5	23 (N), 17 (O)	-
Oral Diagnosis	30	15 – 25	6
Radiography	15	20 – 25	-
Treatment Unit			
Oral and Maxillofacial surgery	-	15 – 20	3
Restorative clinic			
a. Conservative	20 – 30	15	9
b. Prosthetics	60	12 – 3	10
Endodontics clinic	120	7- 8	8
Pedodontics clinic	60	7– 10	10
Orthodontics clinic	-	5	5
Periodontics clinic	45	6	9
Oral Medicine clinic	15′ – 2wks	9	9
Oral Pathology	12′	8-– 10	-
Community Dentistry	-	-	-
Pharmacy	7	20	-

Proposed Model Design

The re-engineering process is as follows: When a patient enters the clinic, (s)he is first attended to by the medical record officer who makes a formal request for payment at the cash office for registration. Then, the patient comes back to the medical record officer to pick the case note. A patient attending the clinic for the first time goes to oral diagnosis from where (s)he is directed to the radiography unit (not all patient goes for radiography) while patient coming based on appointment goes to see the doctor for a check-up. If there is no improvement on the patient tooth, the patient is referred back to the radiography unit to take an x-ray. Required fees for procedures are obtained at the work station from where (s)he proceeded to the cash office to make payment. After treatment, the doctor fixes an appointment date and gives a prescription which is written in the case note and the patient's clinic card. The case note will be dropped with the nurse at the treatment department who will schedule the appointment for patient based on time and then go to the pharmacy for costing of the drug. The patient then pays and gets the drugs. The appointments per department would be fixed based on the number of chairs in each clinic. For example, the prosthetic clinic will have nine chairs, and therefore, seven patients can be attended to at a time with the remaining two chairs reserved for cases of emergency. Patient's appointment batch would be scheduled for 90 minutes interval because it is expected that the patient's appointments would last for 60 minutes and 30 minutes for cleaning up of each cubicle by dental nurses. However, a comprehensive study was carried out on time per procedure per patient in each of the departments. This was used to set up realistic schedules for the patients. The system will also send a reminder message to the patient a day before the appointment date stating the date and time to come for the check-up. The various exiting points for the patient due to one or two reasons are medical record office or oral diagnosis or pharmacy. The proposed workflow process is represented by Figure 5. This proposed workflow process will reduce the time spent in the hospital by the patient due to the elimination of the time in queues for a process and reduction in the going back and forth to a particular point like cash office.

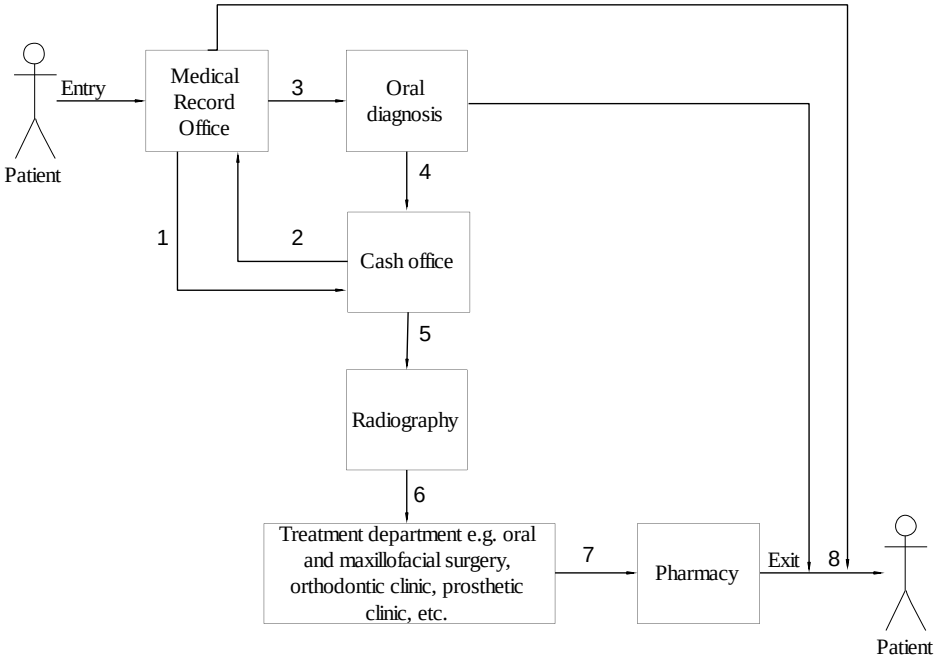

Figure 5: Proposed Work Process Flow

Proposed Model Assumptions

In this study, some assumptions were made which are as listed below:

i. There will be a point of sale terminal at the cash office for patients that do not have enough cash on them but has money in their account. Patients can also pay using online payment. They do not need to go to the cash office for payment thereby reducing the population at the cash office which reduces the time spent paying at the cash office.

ii. A computer system will be stationed at the oral diagnosis which will contain the price list for x-rays, treatments and other dental procedures. It will also be assessing the National Health Insurance Scheme (NHIS) site to check for patients name if they are eligible to benefits from NHIS or membership status.

iii. Available point of payment at the pharmacy.

iv. The appointment scheduling system adopted is a block rule and the time for the appointment will be between the working hours.

The model specification and representation approach used in the study are UML, process maps and Petri net. The UML models consist of use case, sequence and activity diagrams. The process maps model consists of a flowchart and process definition chart. Petri net shows the two possible flows that the patient can follow for either treatment or check-up.

Model representation using Process maps

The order a patient has to go through in achieving treatment process in dental hospitals is represented by the flowchart in Figure 6 while the process definition chart showing the various input and hospital resources required for each activity to be carried out to achieve patient treatment in the proposed workflow model is shown in Figure 7.

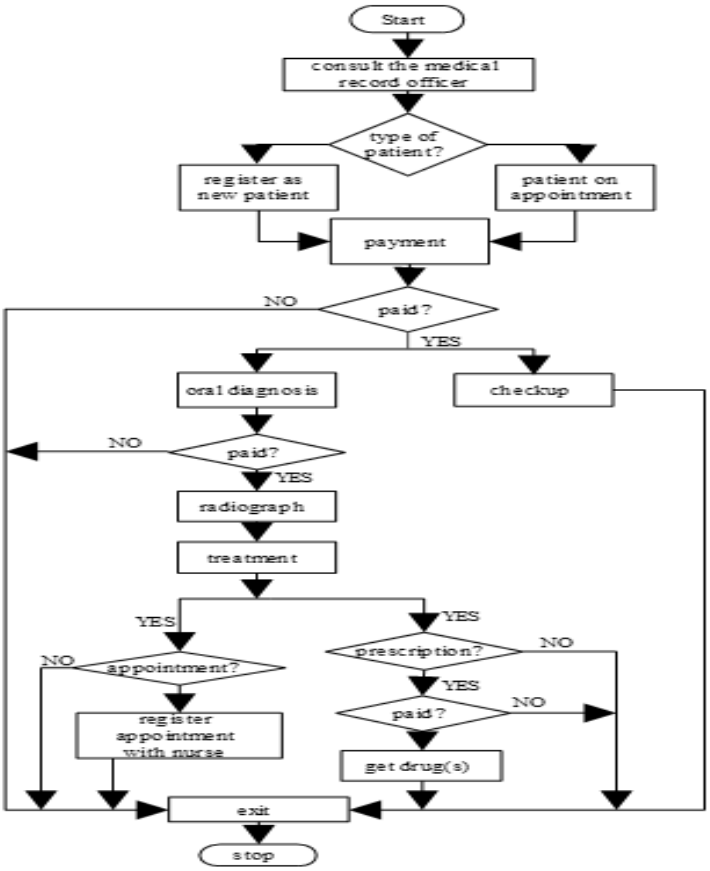

Figure 6: Flowchart of the Proposed Workflow

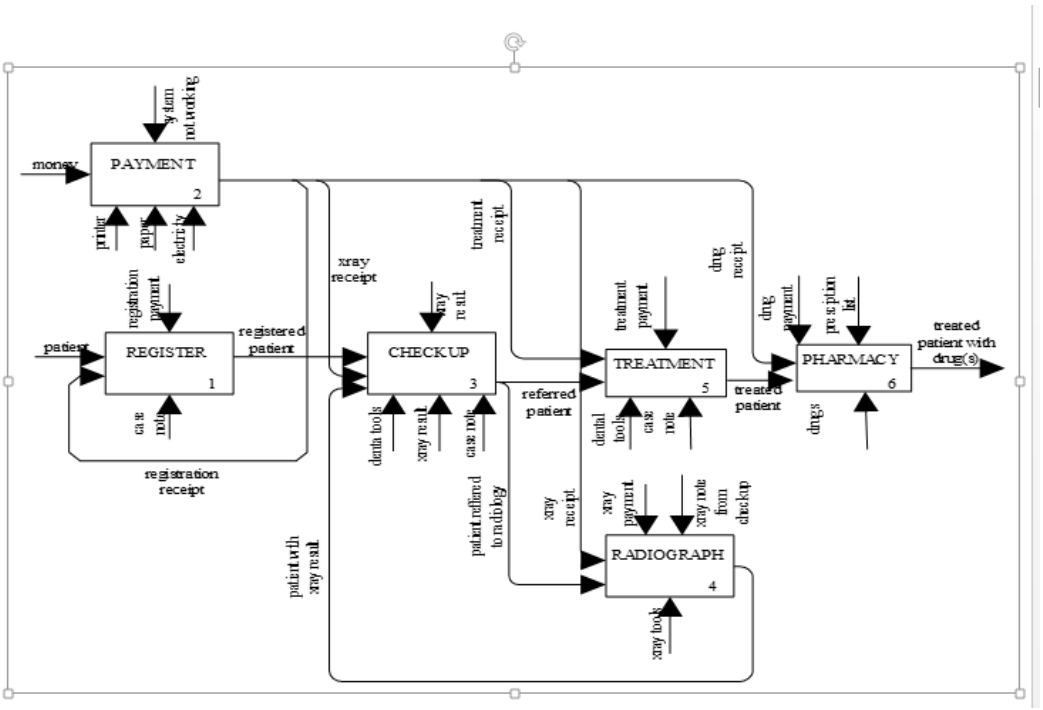

Figure 7: Process Definition Chart of the Workflow

Model representation using Petri net

Patient movement from one point to another within the hospital is represented using Petri net. The new patient goes through the processes (scenario 1), that is, from point q0 to q1 when transition t1 is fired and from q1 to q3 to make payment for registration as new patient when transition t2 is fired, while patients on appointment who come for check-up / review go straight to the treatment unit after making payment at the cash office and retrieved his/her file from the medical record officer (scenario 2), that is, from point q0 to q2 when transition t3 is fired and from point q2 to q3 when transition t4 is fired to make payment for consultation and so on. These are represented below in Figure 8. The patient flow for the scenario 1 is q0,q1,q3,q4,q3,q5,q4,q6,q7,q8,q9,q10 and q0,q2,q3,q4,q3,q7,q8,q9,q10 for scenario 2. The transition table shows the various point a patient can be when a transition is fired. For example,

RESULTS AND DISCUSSION

The existing workflow and the proposed workflow process models were simulated in the same MATLAB environment. They were both subjected to the same input (to ensure that the patient gets the same treatment quality in both models).

The total time taken for the existing workflow process model was 2624.1 seconds (43 minutes 7 seconds) while for the proposed workflow process model was 1212.2 seconds (20 minutes 2 seconds). This is presented in Tables 2 and 3. Thus, the departure time for the existing model is 08:43:07 hh:mm:sec and for the proposed model is 08:20:02 hh:mm:sec. This reduction in time is due to the fact that patient normally go to same cash point to make payment for respective services to be given to them in the hospital which has been eliminated in the proposed workflow process.

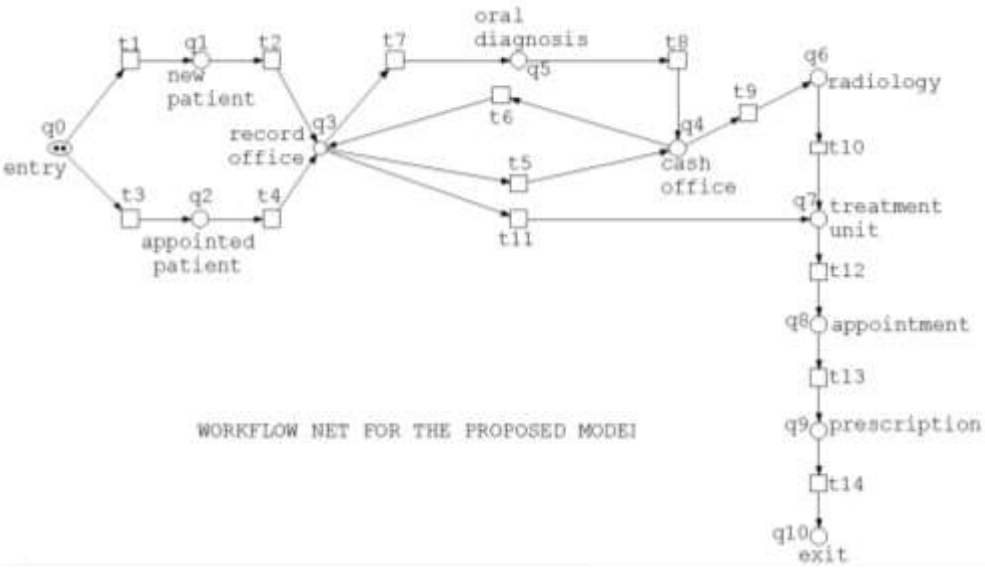

Figure 8: Proposed Workflow Process Representation using Petri net

Table 2: Simulation Result of the Workflow

Activity/Time	Existing Workflow (sec)	Proposed Workflow (sec)
Registration	50.5	50.5
Oral diagnosis	891.0	240.5
Treatment	1000.9	790.5
Pharmacy	681.7	130.7
TOTAL	**2624.1**	**1212.2**

Table 3: Summarization of Total Number of Patients Attended

Activity	Average Number of Patients per day
Registration	23 (N), 17 (O)
Oral Diagnosis	15 – 25
Radiography	20 – 25
1. Oral and Maxillofacial surgery	15 – 20
2. Restorative clinic	
a. Conservative	15
b. Prosthetics	12 – 3
3. Endodontics clinic	7 – 8
4. Pedodontics clinic	7 – 10
5. Orthodontics clinic	5
6. Periodontics clinic	6
7. Oral Medicine clinic	9
8. Oral Pathology	8 – 10
9. Community Dentistry	-
Pharmacy	20

The performance of the proposed workflow process was evaluated by benchmarking it with the performance of the existing workflow process using Patient waiting time (Dinesh *et al.*, 2013), and Patient throughput (Cole, 2004). It was observed that the patient waiting time in the existing model is 1411.9 seconds (23 minutes 54 seconds) more than the proposed model, that is, there is a 36.8% decrease in the total time patient spends in the hospital. The result is as presented in Figure 9. Also, it was observed that the total patient throughput for the existing workflow is 0.462 patient/sec and 0.651 patient/sec for the proposed workflow, the results obtained are as shown in Table 4 and Figure 10.

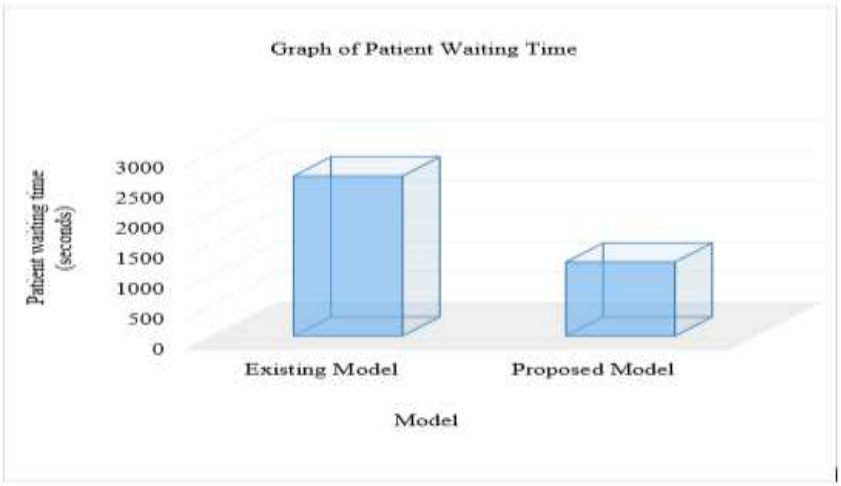

Figure 9: Comparison of the Patient Waiting Time of the Two Models

Table 4: Patient Throughput Summarization

Activity/Patient throughput	Existing Model (patient/sec)	Proposed Model (patient/sec)
Registration	0.396	0.396
Oral diagnosis	0.022	0.083
Treatment	0.015	0.019
Pharmacy	0.029	0.153
Total	**0.462**	**0.651**

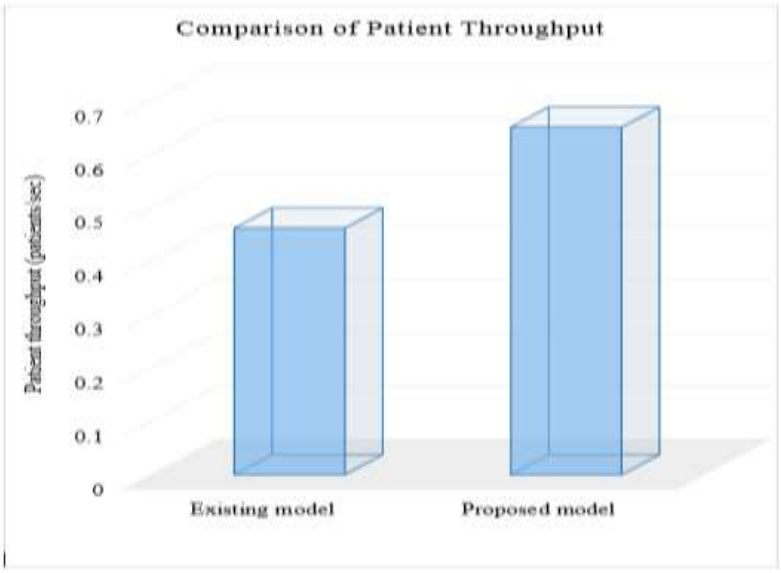

Figure 10: Comparison of the Patient Throughput of the Two Models

CONCLUSION

Applying Business Process Reengineering to the existing OAUTHDC workflow process solved the identified problem in this study by reducing the time it takes a patient to get healthcare service delivery with a reduced number of processes that they have to follow without compromising on the treatment quality. From these results obtained, there is an apparent decrease (1411.9 seconds, 36.8%) in the time spent by the patient in the hospital. The existing model took 2624.1 seconds (i.e., 68.4%) to run while the proposed model took 1212.2 seconds (that is, 31.6%). This implies that patient gets healthcare delivery services in the dental clinic at a faster and easier way as there is a reduction in the number of processes the patient will go through thereby leading to a reduction in the patient waiting time. Also, the rate at which the patient moved from one process to another in the hospital during treatment increased because patients does not have to wait for a service/process before getting attended to due to the fact that there is a reduction in the number of patients waiting to be attended to. Based on this, the hospital will benefit from resource utilization through the efficient use of their resources as more patients will be attended to within a speculated time. Therefore, it is recommended that Nigerian hospitals adopt this proposed model to generate more income as they will be operating at a more effective and efficient way.

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