JOURNAL OF RADIOGRAPHY AND RADIATION SCIENCES

PATIENT WAITING TIME ANALYSIS AT SERVICE POINTS IN THE ULTRASOUND UNIT OF A NIGERIAN TEACHING HOSPITAL

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Received: October 25th 2020 Received in revised form: November 9th, 2020 Accepted: November 10th, 2020

ARTICLE INFO

Keywords:

Patient scheduling, Patients Waiting Time, Ultrasound, Patient service times

ABSTRACT

Background: Quality of service, as perceived by patients in any healthcare facility is to a great extent, dependent on the waiting time. Reducing patients' waiting time increases patients' satisfaction and improves system efficiency.

Purpose: To measure and analyze the waiting time of patients at the service points in the ultrasound unit of a Nigerian tertiary hospital and to determine the mean examination time for the different ultrasound investigations carried out.

Methods: This prospective cross-sectional study was carried out in the ultrasound unit of the Radiology department at University of Nigeria Teaching Hospital (UNTH) Ituku/Ozalla, Enugu. The waiting and examination times of patients were measured directly through observation of system operations. The waiting time at the various service points identified as costing, update, payment and examination were recorded. Mean, range and standard deviation of waiting and service times formed the descriptive statistics for the. For inferential statistics, ANOVA test was carried out to test for significance in the different service point waiting times, and the different examination times for the different investigations.

Results: Mean waiting time was 3 hours 31 seconds and average exam time was 26 minutes 31 seconds. Analysis of variance on the service point where patients wait the most showed that the point after making payment was the most significant. There was no significant difference found in the amount of time spent for different examinations ($P < 0.05$).

Conclusion: Timely delivery of services is of optimum importance, considering the need for patient-centered service. With information provided on the waiting time at the different service points in a typical teaching hospital ultrasound unit, departmental managers will be guided in the planning of the departmental operations, to enhance patient satisfaction and system efficiency.

INTRODUCTION

The current emphasis on improving quality service delivery especially in public health facilities requires a detailed, fundamental understanding of how hospital departments operate. Quality service to patients is hinged on planning and implementation of an efficient patient flow process [1]. In order to eliminate service bottlenecks, reduction of patient waiting time has been shown to be the major focus of patient flow management [2]. One index in healthcare delivery by which the quality of service provided to patients can be evaluated is the uninterrupted movement of patients, known as patient flow, which includes the service times [3, 4].

Patient flow represents the ability of the healthcare system to serve patients quickly and efficiently as they move through stages of care [5]. This patients' service time reduction in turn enhances patient throughput and patients' perception of quality of care they received [6; 7]. Waiting and treatment times are usually regarded as indicators of service quality [8, 9].

The radiology department plays an important role in the patient flow through the hospital. Blockage in the flow can increase waiting and throughput time, creating unnecessary delay at the facility before the patient receives care. This in turn impact negatively on health care outcomes [10]. Lengthy patient waiting time is a major cause of dissatisfaction of patients with healthcare providers [11, 12]. There are different reasons for long waiting times but one major reason observed was the imbalance of the amount of patients in each period [13]. Whether this scenario applies to ultrasound units in a typical Nigerian radiology department is yet to be ascertained.

There is thus need to study the processes involved in getting ultrasound services in a Nigerian tertiary hospital. Considering the Institute of Medicine's (IOM) recommendation on patient's waiting time [14], measuring the waiting times will enable appreciation of how the unit studied complies with the said standard. This is more critical in our society where delay access to diagnostic and medical services can increase the probability of people resorting to self-medication or traditional medicine, which can lead to poor health outcomes. This has necessitated the study of patient waiting and examination time in a Nigerian tertiary Hospital Ultrasound unit.

METHOD

Using systematic random sampling, 395 adult ambulant patients that underwent ultrasound examinations were selected and prospectively observed from arrival to departure from the radiology department of a teaching hospital. The study was carried out at the ultrasound (US) unit of the Radiation Medicine Department, University of Nigeria Teaching hospital (UNTH) Ituku/Ozalla, Enugu state, Nigeria, over a six month period, between March and August, 2019. The study design was cross-sectional.

Based on an average daily patient load of 25, every 5^{th} patient was selected giving a daily sample size of 5 patients. With the help of research assistants, each patient selected was observed directly from entry to exit from the US unit and the waiting time at each service point well captured in an observation sheet provided. Data recorded include: date of examination, type of investigation, patient arrival time at the reception; the costing time at the reception; The update time of patient information at the medical records; The payment time at revenue unit; The waiting time between registration and entry to examination room; The patient examination time in the exam room; and patient departure time from the department Patient flow was observed in real time which enabled understanding of the system operations. All the staff attending to the patients were blind to the study and no effort was made on the part of the observers to facilitate the movement of the selected request forms. The total waiting time of each patient was calculated as a composite of the time they spent in the department from entry to exit.

Data was analyzed using Microsoft statistical software package for social sciences (SPSS) for windows version 21. The quantitative data collected were input in Excel spreadsheet for ease of use in data analysis software. The data was subjected to further refining to ensure all required information were correctly entered and any case with incomplete data either from patient or service information, was excluded from the study.

Patient flow in the system was subjected to queuing analysis. Efficiency of each service point was tested and the probability of bottlenecks in each of the service points was also determined using queuing analysis. Analysis of variance was conducted to test the significance of the variation in service time that exists at various service points, in order to determine the service point where bottleneck mostly occur.

A single channel Poisson arrival and exponential service time model that has one server: M/M/1 queue system, was employed in this work. Additional assumptions of the model were potentially infinite queue and an infinite population.

Performance Measures for the single-channel model are given as follows [15; 16]:

- λ = average arrival rate
- $\frac{1}{\lambda}$ = inter- arrival rate
- μ = average service rate
- $\frac{1}{\mu}$ = inter service rate
- $\frac{\frac{1}{\lambda}}{\frac{1}{\mu}}$ = the service rate
- $\rho = \frac{\text{inter-servicerate}}{\text{inter-arrivalrate}} = \frac{\frac{1}{\mu}}{\frac{1}{\lambda}} = \frac{\lambda}{\mu}$ = the utilization rate (measurement of efficiency of the system).
- $P_n = [1 - (\frac{\lambda}{\mu})](\,(\frac{\lambda}{\mu}))^n$ = the probability that n patients are waiting
- $W = \lambda/(\mu - \lambda)$ = the average waiting time in the system
- $W_q = \lambda/[\mu(\mu - \lambda)]$= the time a patient spends waiting for service
- $P_w = \lambda/\mu$ = the traffic intensity (the probability that a patient arriving will meet a queue)
- The probability that a customer waits in the system more than "t" is $P(X>t) = e^{-(\mu-\lambda)t}$

RESULTS

The existing appointment system which applied in the ultrasound unit under study was the single block rule where all the patients were booked to arrive at the same time. The patients were served on a first come first serve basis. The queue system is single channel with single server. The current queue model is M/M/1/I, which means the pattern is random arrival. The service pattern is also random that follows Poisson distribution. The number of facilities is only one with infinite population. The queue model and workflow process are shown in Fig 1a and 1b respectively.

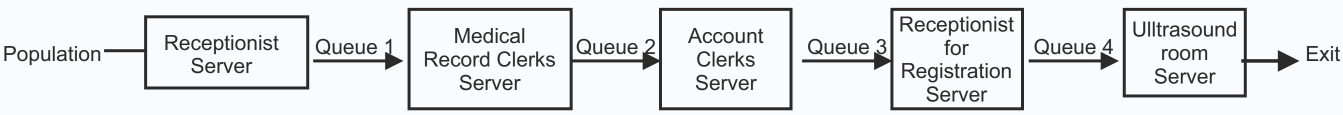

Fig 1a: Process flow of patients through the ultrasound unit.

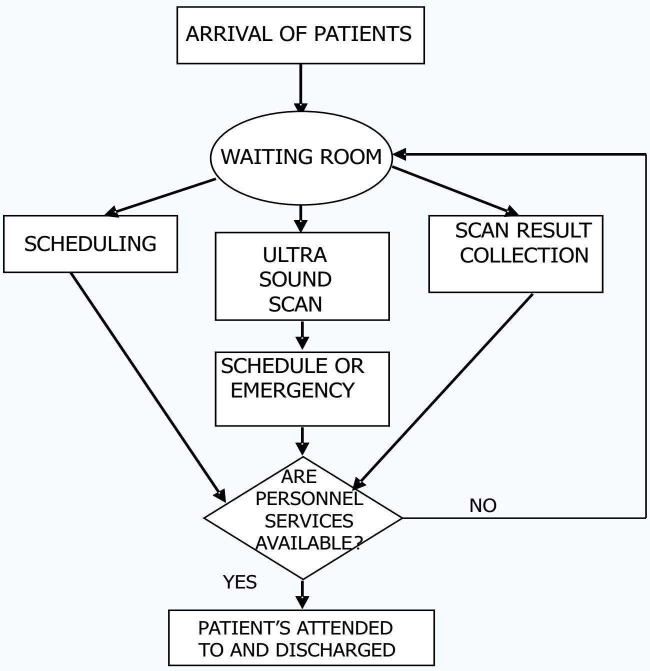

Figure 1a and 1b enabled understanding of the processes involved in the ultrasound unit patient flow. All the waiting points in the process as well as the services provided were shown.

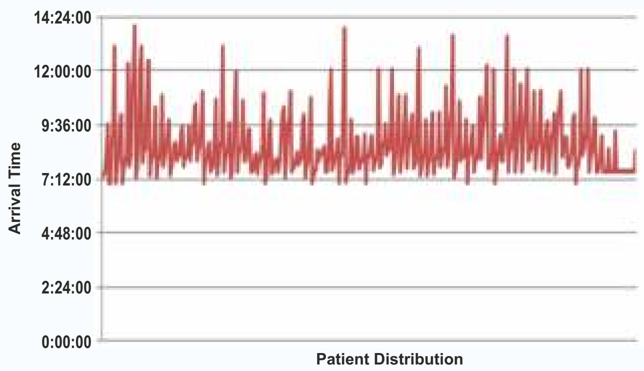

Figure 2: Patient arrival pattern

Figure 2 shows the overall patient daily arrival distribution for the observed period of study. About 75.44% of the total number of sampled patients arrived between 7:12 - 9:36hrs, 4.1% of the patients arrived earlier than 7:12hrs, 13.9% arrived between 9:37 and 12:00hrs while 2.8% arrived between 12:01 and 13:59hrs. This translates to high patient arrivals for early hours of each day and lower arrival rates as the day progresses.

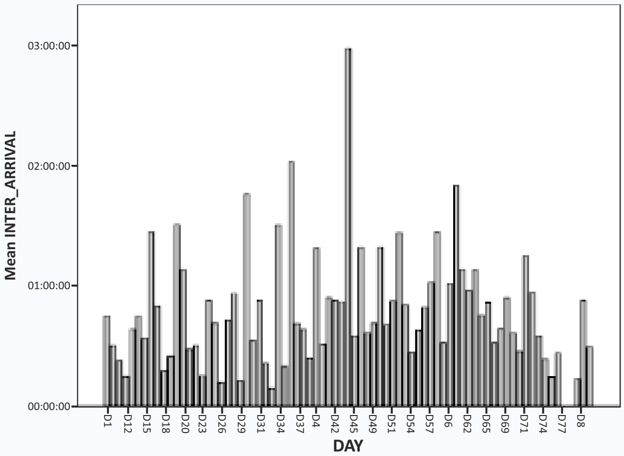

Fig 3: Patient daily inter-arrival rate for the period of study

Figure 3 shows patient's daily inter- arrival time for the period of study. It can be observed that 56% of the sampled patient used 0-30 minutes time duration for successive arrivals, 20.40% used 31-60 minutes for successive arrivals while 11.30%, 4.90% and 7.10% used 61-90,91-120 and >120 minutes respectively for successive arrivals.(see appendix 1). The most occurring inter- arrival time was 15 minutes. Daily inter arrival rate was calculated for the period of study to get the overall inter-arrival rate. The inter-arrival rate ($\frac{1}{\lambda}$) was calculated to be:

$$\frac{1}{\lambda} = \frac{1}{0:44:14} \text{ minutes or } \frac{1}{2654} \text{ seconds} = 0.000376\text{hrs}$$

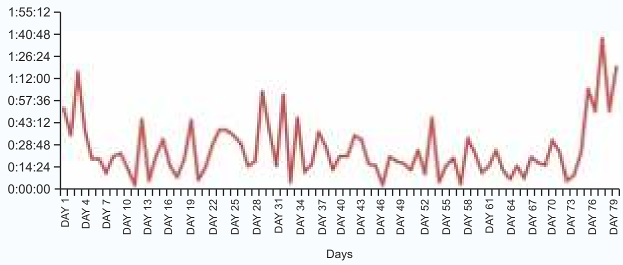

Fig 4a: Average patient waiting time in costing service point

Fig 4a shows average patient waiting time in costing service point. Above 49.4% of the sampled patient waited between 0-20 minutes, 30.4% waited between 20-40minutes, 8.8% waited between 40-60 minutes while 11.4% waited for more than 60minutes. It was also observed that the minimum wait time for costing was 02:24 (2 minutes 24 seconds) while the maximum wait time is 1:37:47 (1 hour, 37minutes 47 seconds) (see appendix 2a). The overall average wait time of patients for costing was (μ= 0:25:30) 25 minutes 30 seconds. The service rate given as

$$\frac{\frac{1}{\lambda}}{\frac{1}{\mu}} = \frac{\frac{1}{0:44:14}}{\frac{1}{0.2530}} \text{ minutes or } \frac{\frac{1}{2654}}{\frac{1}{1530}} \text{ seconds} = 0.000000246\text{hrs.}$$

The utilization rate (measurement of efficiency of the system)

$$\rho = \frac{\textit{inter-servicerate}}{\textit{inter-arrivalrate}} = \frac{\frac{1}{\mu}}{\frac{1}{\lambda}} = \frac{\lambda}{\mu} = \frac{1530}{2654} = \mathbf{0.576 \cong 56.6\%.}$$

This implies that the probability that a patient will meet a queue at the point of costing is 0.58.

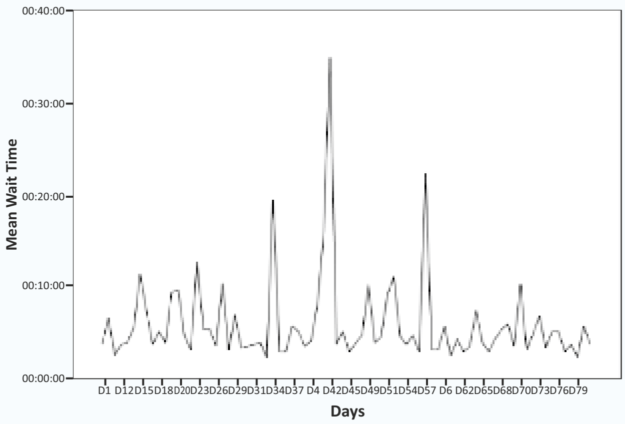

Fig 4b: Average Patient update Time for the observed Period

From the Figure 4b, it can be seen that 90.40% of the sampled patients waited < 10 minutes (< 600 Seconds) at the point of update, 2.80% waited between 10-20 minutes (600 -1200 Seconds) while 2.30% and 2.50% of the patients waited between 20 – 30 minutes (1200 – 1800 seconds) and > 30 (>1800 seconds) respectively(see appendix 2b). The overall patient mean waiting time for update was 0:06:08 minutes (six minutes eight seconds), while service rate at the point of patient's update was

$$\frac{\frac{1}{\lambda}}{\frac{1}{\mu}} = \frac{\frac{1}{0:44:14}}{\frac{1}{0.06:08}} \text{ minutes or } \frac{\frac{1}{2654}}{\frac{1}{368}} \text{ seconds} = 0.00000985\text{hrs}$$

the utilization rate (measurement of efficiency of the system)

$$\rho = \frac{\textit{inter-servicerate}}{\textit{inter-arrivalrate}} = \frac{\frac{1}{\mu}}{\frac{1}{\lambda}} = \frac{\lambda}{\mu} = \frac{368}{2654} = \mathbf{0.138 \cong 13.8\%.}$$

This implies that the probability that a patient will meet a queue at the point of update is 0.14.

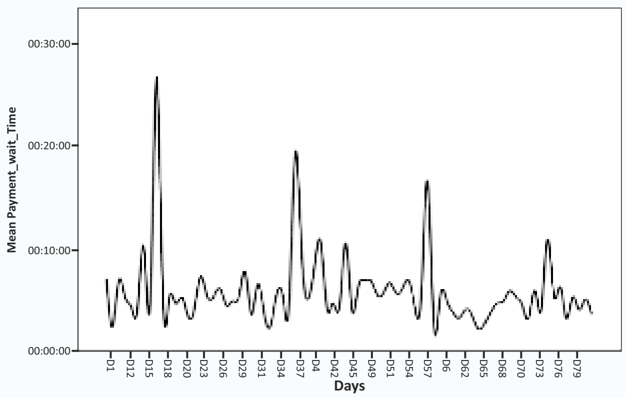

Fig 4c: Average Patient's Payment Time for the Observed Period

On Figure 4c it can be seen that 76% of the patients spent 0-5 minutes, 16.7% spent 6-10 minutes while 2.5% spent more than 30 minutes (see appendix 2c) wait time at payment service point. The most occurring time duration was 4 minutes. The mean wait time of patients for payment was 6 minutes 7 seconds. The inter service rate for payment is given as

$$\frac{\frac{1}{\lambda}}{\frac{1}{\mu}} = \frac{\frac{1}{0:44:14}}{\frac{1}{0.06:07}} \text{ minutes or } \frac{\frac{1}{2654}}{\frac{1}{367}} \text{ seconds} = 0.00000103\text{hrs}$$

and the utilization rate (measurement of efficiency of the system) as

$$\rho = \frac{\textit{inter-servicerate}}{\textit{inter-arrivalrate}} = \frac{\frac{1}{\mu}}{\frac{1}{\lambda}} = \frac{\lambda}{\mu} = \frac{367}{2654} = \mathbf{0.143 \cong 14.3\%.}$$

This implies that the probability that a patient will meet a queue at the point of payment is 0.14.

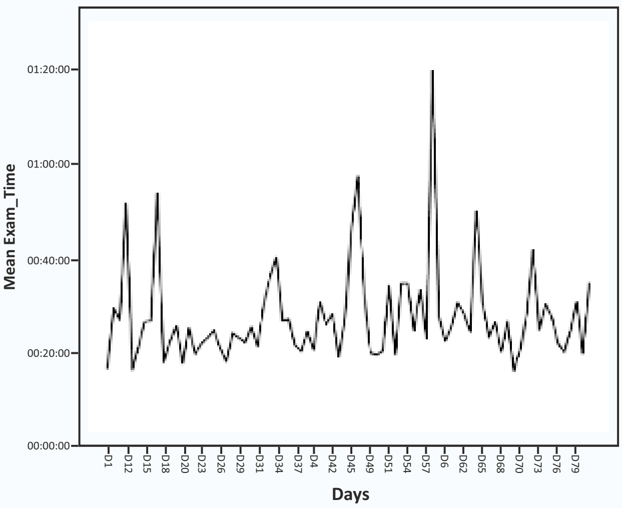

Fig 4d: Average Patient's exam time for the Periods under Review

Figure 4d shows patients' exam time for the period of study. From the figure it can be observed that majority of the exams were done between 10- 20 minutes. The average exam time was 26minutes 31 seconds (see appendix 2d) which implies that the inter-service rate

$$\frac{\frac{1}{\lambda}}{\frac{1}{\mu}} = \frac{\frac{1}{0:44:14}}{\frac{1}{0.26:13}} \text{ minutes or } \frac{\frac{1}{2654}}{\frac{1}{1591}} \text{ seconds} = 0.00000103\text{hrs}$$

and the utilization rate (measurement of efficiency of the system) as

$$\rho = \frac{\textit{inter-servicerate}}{\textit{inter-arrivalrate}} = \frac{\frac{1}{\mu}}{\frac{1}{\lambda}} = \frac{\lambda}{\mu} = \frac{1591}{2654} = \mathbf{0.599 \cong 59.9\%.}$$

This implies that the probability that a patient will spend time during examination is≅0.60.

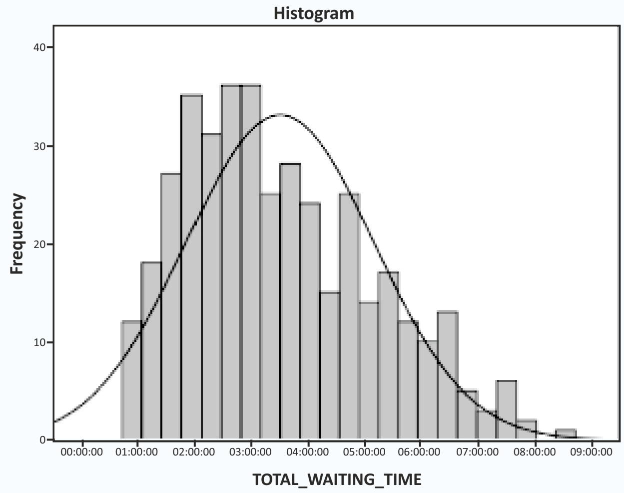

Fig 5: Distribution of patient's total waiting time in the system

Figure 5 shows daily total wait time of patient in the system. It can be seen that minimum total wait time in the system was 45 minutes and the maximum wait time was 8 hour 40 minutes. The overall mean waiting time was 3 hours 31 minutes 24 seconds while the overall system utilization

$$\rho = \frac{\textit{servicerate}}{\textit{inter-arrivalrate}} = \frac{\mu}{\frac{1}{\lambda}} = \frac{\lambda}{\mu} = \frac{2654}{14544} = \mathbf{0.182.}$$

This gives the probability that any patient coming will have to wait for service.

Table 2: Distribution of examination time for different investigations

EXAM TIME (Minutes)	Exam Type and Number of Patients SMALL PARTS	ABDOMINO/PELVIC SCAN	OBSTETRICS EXAM	SONOMAMO EXAM
<5MINS	2	8	0	1
6 - 10 MINS	2	3	1	2
11-15 MINS	20	48	31	14
16- 20 MINS	14	38	27	6
21-25 MINS	18	27	11	5
26-30 MINS	12	19	9	2
>30 MINS	24	27	17	7
TOTAL	92	170	96	37

Descriptive Statistics of exam time (mins)				
MEAN	0:28:23	0:25:08	0:24:58	0:22:30
Std Deviation	0:24:02	0:22:24	0:22:56	0:16:00
MINIMUM	0:05:00	0:05:00	0:09:00	0:05:00
MAXIMUM	3:20:00	2:55:00	2:40:00	1:08:00
RANGE	3:15:00	2:50:00	2:31:00	1:03:00

It can be seen from Table 2 that for the period of study, a total of 92 patients came for small parts scan, 170 patients came for abdomino-pelvic examinations, while for obstetrics and sonomammo 94 and 37 patients respectively were examined. Small parts scan had mean time of 28 minutes 49 second with minimum exam time of 5 minutes and maximum exam time of 3hrs 20 minutes. Abdomino-pelvic exam had exam mean time of 25 minutes 8 second with minimum and maximum exam time of 5minutes and 2hrs 55minutes respectively. Obstetrics had mean exam time of 24 minutes 58 seconds with minimum and maximum exam time of 9 minutes and 2hrs 40 seconds respectively while Sonomammo had mean exam time of 21 minutes 6 second with maximum and minimum exam time of 1hr 8 minutes and 5 minutes respectively.

From the table, it can be concluded that small parts scan was the exam with the highest mean time, which implied that small parts examination took more time than other examinations in this study.

Table 3: Variation between different service wait times [ANOVA]

Service Points	F	Sig.
COSTING	2.535	.028
UPDATE	.483	.974
PAYMENT	7.162	.000
EXAM	1.120	.430

Table 3 measured the significance of differences in mean wait time of all service points in order to determine the service point with most significant wait time. From the table, it can be seen that the service point with most significant wait time was Payment as its p-value lies on the zero region ($p < 0.05$). This implies that patient spent more time at the point of making payment than in any other service point.

Table 4: Tests of Between-Subjects Effects

Dependent Variable: Exam Time

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	4210111.874[a]	3	1403370.625	.780	.506
Intercept	706224306.133	1	706224306.133	392.292	.000
EXAM_TYPE	4210111.874	3	1403370.625	.780	.506
Error	703898495.721	391	1800251.907		
Total	1637820000.000	395			
Corrected Total	708108607.595	394			

a. R Squared = .006 (Adjusted R Squared = -.002)

Table 4 showed that there was no significant difference in the amount of time spent for different examination as $P > 0.05$. This implied that time spent by patient for exams was the same irrespective of the type of examination.

DISCUSSION

Patients in the facility, as observed during the study, were booked in advance using single block scheduling method. This entailed giving all the patients the same appointment time of 7.30am on their appointment date. Many researchers, based on observation of long waiting times with this method, have recommended the use of individual-block/fixed interval system where peculiar appointment times are given to patients evenly distributed throughout the day [17; 18].

Patients' arrival time pattern for scan was demonstrated to be highly stochastic with the peak arrival hours within 7:12 - 9:36hrs. This was also observed to decrease as the day progresses and agrees with the findings of Yogesh et al., [19] in which patients' arrival was also found to be highly stochastic. However, their study showed different peak hours which could be attributed to different time zones. Early arrival of patients is known to cause prolonged waiting times among patients as those who arrived early waited the longest [20]. It is also associated with stress among staff [18].

Inter- arrival time was used to determine time interval between successive arrivals for each day of the week. It was observed that successive arrivals take place within 30 minutes as it was observed that 56% of the sampled population arrived within the time duration. Inter- arrival rate was calculated to be 1/44 minutes 14 seconds. This goes to show the intensity of the patient flow traffic.

Service for ultrasound examination in the institution was divided into four segments which includes; costing, update, payment and examination. At each of the service points, patients encountered bottlenecks. Investigation was done to determine the service point where bottlenecks mostly occurred. Result showed that the probability that a patient will meet a queue was 0.58; update and payment showed the same probability of 0.14 while examination had the probability of queue calculated to be 0.60. This implies that patient experience delays at the point before examination. Thacher in analyzing patient waiting time in a hospital outpatient unit, categorized the service points and identified waiting on queue to see the doctor constituted a major source of service bottlenecks [21]. The patients had to wait an average of 152minutes to see a doctor, the actual consultation lasing on the average 9.6minutes.

The overall mean waiting time was 3 hours 31 minutes 24 seconds. This agrees with the study carried out by Sing et al., [22] in Trinidad and Tobago with mean wait time of 2hrs 40 minutes. Long wait times is associated with decrease in patient satisfaction which adversely affects patient no-show rate [23]. It can be attributed to the scheduling pattern and very few operational ultrasound machines available in the unit. The result obtained showed that the point of making payment was the most significant as $P < 0.05$ which implies that patient experience delays at the point after payment to when they are called for examination. The patient mean waiting time is different from the mean waiting time of 85 minutes (1 hour 25 minutes) recorded in a study by Umar et al., [24]. Disparity in the number of facilities may explain the differences observed.

Majority of the examinations (47.80%) were done between 10- 20 minutes, while the average examination time was 26 minutes 31 seconds. This agrees with results from ultrasound exam lengths survey analysis by the society and college of radiographers where the modal exam time was 20 minutes [25]. The findings are however at variance with mean exam time of 3 minutes recorded in a study carried out by Singh et al. [22]. They also observed that 47% of patients expressed dissatisfaction over the 3minutes mean exam time.

Further analysis of examination time for different ultrasound scans showed that small parts scan showed the highest mean examination time. This implies that small parts examination took more time than other examinations that presented during this study. Analysis of variance was conducted to test the significance of the variation of exam time difference that exists between the different types of ultrasound scans. The result obtained showed that there was no significant difference in the amount of time spent for different examination as $P > 0.05$.

CONCLUSION

Ultrasound units are noted for diagnostic related services to patients. Sub-optimal patient service arises when delay in service delivery is encountered. The waiting and examination times were measured and analyzed for a typical ultrasound unit in a Nigerian tertiary hospital. Variation in waiting time was observed across the different service points but there was no significant difference in the examination time recorded for the different investigations carried out. The radiology department managers will be guided with the information provided, in addressing ultrasound unit service bottlenecks through good patient flow management. With this, the patient satisfaction will be enhanced and the system efficiency will be improved.

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