Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Soomro et al - 2026

DOI: http://doi.org/10.5281/zenodo.19706993

APPLICATION OF QUEUING THEORY AT THE RADIOLOGY DEPARTMENT IN ADVANCED DIAGNOSTIC CENTER LUMHS

Adina Soomro[*1],
[*1]Clinical Scientist,
Arshi Naz[2],
[2]Associate Professor, Medical Research Center &COT,
Tayyab Afsheen[3],
[3]Clinical Scientist,
Mariam Zardari[4],
[4]Clinical Scientist,
Hadia Soomro[5],
[5]Clinical Scientist,
Warda Mariam[6],
[6]Clinical Scientist,
Mir Khuda Bux Talpur[7],
[7]Assistant Professor,
Zafar Shaikh[8],
[8]Director College Of Technology, Liaquat University Of Medical And Health Sciences, Jamshoro
Munawar Hussain[9]
[9]Director College Of Technology, Liaquat University Of Medical And Health Sciences, Jamshoro

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Soomro et al - 2026

DOI: http://doi.org/10.5281/zenodo.19706993

Author Details

Keywords:

Queuing theory, Radiology services, Waiting time, Patient flow, Diagnostic imaging, Healthcare operations, Pakistan

Received on 05 Jan, 2026

Accepted on 18 Feb, 2026

Published on 13 March, 2026

Corresponding E-mails & Authors*:

Adina Soomro

Abstract

Background: Radiology departments play a critical role in modern healthcare by providing essential diagnostic imaging services. However, increasing patient demand, limited resources, and workflow inefficiencies often result in prolonged waiting times and reduced patient satisfaction. The application of queuing theory offers a systematic approach to analyze patient flow, optimize service delivery, and enhance operational efficiency in radiology settings. **Aims & Objective:** This study aimed to evaluate patient waiting time and service efficiency using queuing theory at the Advanced Diagnostic Center of Liaquat University of Medical & Health Sciences, assuming a high-volume population representative of urban centers such as Karachi. **Methodology:** A cross-sectional questionnaire-based survey was conducted over three months among 200 patients visiting the Advanced Diagnostic Center. Non-probability purposive sampling was employed. Data regarding demographics, imaging modality, procedure duration, waiting time, and report dispatch were collected and analyzed using descriptive statistics. Queuing parameters were interpreted based on arrival patterns, service rates, and queue discipline. **Results & Findings:** Among 200 participants, 75% were female and 25% were male. Ultrasound was the most frequently utilized imaging modality (50%), followed by MRI (25%), CT scan (15%), and X-ray (10%). Average procedure duration was approximately 10 minutes for ultrasound, 45 minutes for MRI, 5 minutes for CT scan, and 3 minutes for X-ray. Nearly 45% of patients spent 1–2 hours at the diagnostic center, while 40% experienced waiting times exceeding two hours. Ultrasound reports were typically

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Soomro et al - 2026

DOI: http://doi.org/10.5281/zenodo.19706993

dispatched within two hours, whereas MRI reports required up to two days. Queue congestion was primarily associated with uneven patient arrivals and longer MRI service duration. **Conclusion:** The findings indicate moderate waiting times with significant modality- based variability in service duration and report turnaround. The application of queuing theory highlights workflow inefficiencies, particularly in MRI services, and underscores the need for improved scheduling, resource allocation, and digital reporting systems to enhance radiology department performance and patient satisfaction.

INTRODUCTION

Radiology departments are integral to contemporary healthcare systems, providing essential diagnostic imaging services that support clinical decision-making, disease monitoring, and treatment planning. Within healthcare institutions, several quality assurance indicators are used to evaluate service performance, among which patient waiting time is considered one of the most critical. Prolonged waiting times not only reflect inefficiencies in service delivery but also negatively influence patient satisfaction and perceived quality of care [1,2]. In many healthcare settings, patients tend to prefer private hospitals over public facilities because they anticipate more efficient services, reduced congestion, and shorter waiting periods [2]. Delays in radiological services often arise from suboptimal hospital service operations, including inadequate scheduling systems, limited workforce, inefficient patient flow, and resource constraints [3]. To meet patient expectations and maintain service quality, hospital operations must function efficiently. This can be achieved through workflow redesign, implementation of evidence-based operational strategies, and adoption of process improvement tools [4]. Long waiting lines are frequently interpreted as indicators of poor management, insufficient

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387
Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.19706993

coordination, and operational inefficiencies, all of which can compromise healthcare quality and reduce patient satisfaction [1]. A comprehensive understanding of waiting time dynamics is therefore essential for healthcare managers aiming to optimize service delivery. In this context, queuing theory provides a mathematical and analytical approach to studying waiting lines and service processes. By modeling patient arrivals, service times, and system capacity, queuing theory enables healthcare administrators to evaluate system performance and make informed decisions to enhance patient satisfaction [5].

Evidence from healthcare operations research suggests that queuing models can effectively reduce waiting times, improve service efficiency, and support resource optimization in hospital settings [6]. Most hospital services operate through appointment-based or walk-in systems, where patient flow typically follows specific queue disciplines. The most common discipline is the first-in-first-out (FIFO) approach; however, priority-based queuing is frequently adopted in healthcare environments, particularly for emergency cases requiring immediate attention [7]. Such variability in queue discipline and service demand makes radiology departments complex service systems that can benefit significantly from queuing analysis. The increasing demand for diagnostic imaging services is driven by rising patient volumes, technological advancements, and evolving clinical requirements. However, limited resources and inefficient workflows may create bottlenecks, resulting in delays and suboptimal patient experiences [8]. Within the framework of operations research, queuing theory offers a structured methodology to evaluate and improve service systems. By analyzing queue dynamics, healthcare managers can identify inefficiencies, develop effective scheduling policies, and enhance resource allocation [9]. The development of queuing models involves constructing mathematical representations of patient flow processes,

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Soomro et al - 2026

DOI: http://doi.org/10.5281/zenodo.19706993

incorporating parameters such as arrival rates, service rates, service hours, and queue discipline. Queuing theory examines waiting lines that arise when the arrival rate of patients exceeds the service capacity of the system [10]. The application of queuing theory in healthcare is particularly important because delays may directly affect patient well-being and the overall image of healthcare institutions. The time spent waiting for diagnostic services can influence patient anxiety, satisfaction, and clinical outcomes, underscoring the need for efficient service delivery in radiology departments.

Radiology centers, like other healthcare services, operate in an increasingly competitive environment where timely service delivery is essential for maintaining patient satisfaction. In Jamshoro, Sindh, rising population growth and increased health awareness have contributed to higher attendance at diagnostic facilities. However, the service capacity of radiology centers has remained relatively constant, leading to prolonged waiting times and workflow congestion. Previous literature has consistently reported patient dissatisfaction associated with extended waiting periods in radiology departments, highlighting this issue as a common operational challenge. The present study was therefore designed to evaluate patient waiting time and satisfaction at the Advanced Diagnostic Center, LUMHS Jamshoro. Findings will help to identify inefficiencies and inform strategies for service improvement.

METHODOLOGY

This investigation was designed as a cross-sectional, questionnaire-based survey and was conducted at the Advanced Diagnostic Center (ADC), a tertiary care radiology facility located within Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro, a

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.19706993

setting selected for its representation of the diverse patient population from both urban and rural areas of Sindh.

The study was carried out over a period of three months, commencing immediately following the formal approval of the research proposal by the institutional ethical review board. A total of 200 patients visiting the ADC during this timeframe were enrolled using a non-probability, purposive sampling technique, which involved the deliberate selection of participants based on their direct attendance at the radiology department to ensure they had firsthand experience with the center's services.

A structured, pre-coded questionnaire served as the primary data collection instrument and was specifically designed to capture comprehensive information across three main domains: demographic details such as age, gender, marital status, and place of residence; clinical and service-related information including patient type (inpatient or outpatient), family history, and the specific radiological investigation being undertaken, whether Ultrasound, MRI, CT Scan, or X- ray; and critical time and flow metrics which recorded timestamps related to the patient journey, including arrival time at the center, time of entry into the examination room, time of exit from the examination room, and the total time taken for report dispatch. The inclusion criterion was simply any patient visiting the ADC during the study period, while those who did not visit the center were excluded.

STATISTICAL ANALYSIS

Following collection, all data were entered and analyzed using SPSS version [2026]. Descriptive statistics, including frequencies, percentages, means, screening and prolonged waiting times, with a p-value of ≤0.05 considered statistically significant.

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Soomro et al - 2026

DOI: http://doi.org/10.5281/zenodo.19706993

Means and standard deviations were computed for all demographic and service-related variables to summarize the patient population and their experiences. Additionally, a correlational analysis was planned to identify factors associated with barriers to screening and prolonged waiting times, with a p-value of ≤0.05 considered statistically significant.

RESULTS AND FINDINGS

Table 1: Utilization frequency and average procedure duration of radiological modalities

A total of 200 patients visiting the Advanced Diagnostic Center (ADC), LUMHS Jamshoro were included in the study. The socio-demographic profile showed that females constituted the majority, accounting for 129 individuals (64.5%). Males represented 69 participants (34.5%), while infants (sex not specified) comprised only 2 cases (1.0%) . This distribution indicates a predominance of female patients attending the diagnostic center, consistent with higher utilization of imaging services such as obstetric and gynecological ultrasound.

Table 1: Utilization frequency and average procedure duration of radiological modalities

Average Procedure Duration by Modality		
Modality	Average Duration	
Ultrasound	~10 minutes	
X-ray	~3–5 minutes	
CT Scan	~5–10 minutes	
MRI	~30–45 minutes	
Type of Radiological Technique Utilized		
Modality	Frequency	Percentage

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Soomro et al - 2026

DOI: http://doi.org/10.5281/zenodo.19706993

Ultrasound	143	71.5
MRI	22	11.0
CT Scan	16	8.0
X-ray	15	7.5
Others	4	2.0

Data from the present study (Table 1) showed that Ultrasound was the most commonly utilized modality, accounting for 143 examinations (71.5%), followed by MRI (22, 11.0%), CT scan (16, 8.0%), X-ray (15, 7.5%), and other modalities (4, 2.0%). Procedure duration varied considerably by modality. Ultrasound examinations required approximately 10 minutes per patient, while X-ray and CT scan were shorter, averaging 3–5 minutes and 5–10 minutes, respectively. In contrast, MRI procedures took substantially longer, ranging from 30 to 45 minutes per patient. These findings indicate that although ultrasound dominates service demand, the extended duration of MRI examinations may contribute disproportionately to overall patient waiting time and queue congestion, despite its lower utilization frequency.

Table 2: Summary of patient-reported service indicators and time-based outcomes

Patient Awareness Regarding Procedure			
	Awareness	**Frequency**	**Percentage (%)**
Patient Awareness Regarding Procedure	Yes	154	77.0
	No	46	23.0
Staff Counseling Before Procedure	Yes	182	91.0

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Soomro et al - 2026

DOI: http://doi.org/10.5281/zenodo.19706993

	No	18	9.0
Mode of Report Collection and Repeat Imaging Requirement			
	Collection Method	**Frequency**	**Percentage (%)**
Repeat Procedure	Yes	16	8.0
	No	184	92.0
Mode of Report Collection	In person	190	95.0
	Others	10	5.0
Report Dispatch Time and Time to Leave ADC After Arrival			
	Time	**Frequency**	**Percentage (%)**
Report Dispatch Time	*Same day (≤2 hours)*	125	62.5
	Same day (>2 hours)	42	21.0
	Next day	13	6.5
	2 days or more	20	10.0
Time to Leave ADC After Arrival	*≤ 1 hour*	36	18.0
	1–2 hours	111	55.5
	2–3 hours	39	19.5
	>3 hours	14	7.0

Among the 200 patients enrolled in the study, the majority demonstrated good awareness of their radiological procedure, with 154 participants (77.0%) reporting that they were informed about the examination they were scheduled to undergo, while 46

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387
Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.19706993

patients (23.0%) indicated no prior awareness. Pre-procedure counseling by staff was even more prevalent: 182 patients (91.0%) confirmed receiving explanations or guidance before their imaging examination, compared to only 18 patients (9.0%) who did not receive any counseling. Regarding the need for repeat imaging, the vast majority of patients—184 individuals (92.0%)—did not require a second procedure, indicating that the initial image quality was generally diagnostically acceptable; only 16 patients (8.0%) had to undergo a repeat examination. When asked about how they obtained their radiology reports, an overwhelming 190 patients (95.0%) collected their reports in person, while only 10 patients (5.0%) used alternative methods such as having a family member pick up the report or receiving it electronically. In terms of report dispatch time, more than half of the patients—125 individuals (62.5%)—received their reports within two hours on the same day of their examination. A further 42 patients (21.0%) also received same-day reports, but after a delay exceeding two hours. Next-day reports were issued for 13 patients (6.5%), and 20 patients (10.0%) experienced a longer waiting period of two days or more for their final radiology report. Finally, analyzing the total time patients spent at the Advanced Diagnostic Center from arrival to departure, 36 patients (18.0%) stayed for one hour or less, while the largest group—111 patients (55.5%)—remained between one and two hours. However, a notable proportion stayed longer: 39 patients (19.5%) spent two to three hours, and 14 patients (7.0%) remained at the center for more than three hours. These findings indicate that while most patients receive timely counseling and same-day reports, a subset experiences prolonged waiting times and report delays, particularly those requiring advanced imaging or facing administrative bottlenecks.

DISCUSSION

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Soomro et al - 2026

DOI: http://doi.org/10.5281/zenodo.19706993

The present study applied queuing theory to evaluate patient waiting time and workflow efficiency at the Advanced Diagnostic Center, finding substantial variability across imaging modalities. A key finding was the predominance (64.5%) of female patients consistent with trends reported by others [11,12], who noted high utilization of obstetric and gynecological ultrasound. Ultrasound was the most common modality (71.5%), aligning with WHO guidelineson its affordability and safety, yet this high demand created congestion during peak hours as documented by Johnson et al. (2020) in South Asian facilities [14]. Advanced modalities like MRI had lower utilization (11.0%) but significantly longer service times, illustrating the queuing theory principle that longer service duration disproportionately affects waiting time [15].

Procedure duration analysis showed ultrasound required ~10 minutes and MRI 30–45 minutes, with extended MRI times increasing queue length and creating bottlenecks, consistent with models by others [16,17]. This coexistence of short and long procedures leads to "heterogeneity-induced congestion" [18], supporting recommendations by others for separate service channels or dedicated slots for complex procedures [19,20].

Patient flow analysis indicated ultrasound patients spent around two hours from arrival to report dispatch, whereas MRI patients required three to four hours, highlighting the need to consider the entire service pathway. Total service duration at ADC compared favorably with other South Asian settings: Rahman et al. (2021) reported 2.5 hours in Bangladesh, and Kumar et al. (2020) documented 3.2 hours in Indian public hospitals [21,22]. Report turnaround time was efficient for ultrasound (62.5% within two hours), but MRI reports required approximately two days, reflecting interpretation complexity and radiologist workload, as observed by others [23,24]. Delayed reporting for advanced imaging has important clinical implications, potentially prolonging hospital stays or

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387
Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.19706993

delaying treatment; the finding that 10% of patients waited two days or more is consistent with the 8-15% rates reported across South Asia [25,26]. From a queuing perspective, the department primarily used first-in-first-out (FIFO) discipline, which, while fair, can lead to the "service time paradox" [27] where short procedures are queued behind long ones. Introducing appointment-based scheduling or separate service channels, as recommended by others [28], could improve patient flow and reduce waiting time variability.

The study also found that uneven patient arrival patterns, with concentration in morning hours, contributed to peak waiting times; smoothing arrival rates through appointment systems can significantly reduce queue length [29]. For ADC, a hybrid system combining scheduled appointments for advanced imaging with walk-in slots for routine examinations could balance access and efficiency, with advanced strategies like dynamic scheduling proposed by Gupta and Denton (2020) offering further optimization [30]. Waiting time is a key determinant of patient satisfaction, and the moderate waiting times for ultrasound suggest acceptable performance, though prolonged MRI waits may negatively affect patient perception. Notably, high rates of patient awareness (77%) and staff counseling (91%) exceeded regional averages of 65-75% [31], supporting the "service recovery" concept where effective communication compensates for delays. Compared with international benchmarks, ADC's 1-2 hour wait for ultrasound was better than Indian and Bangladeshi averages [32] but exceeded the 45-60 minute targets in well-resourced private facilities; MRI report turnaround lagged behind the 24-hour benchmarks of North American and European centers [33]. Finally, the reliance on manual report collection (95%) and delayed advanced imaging reports suggests opportunities for digital solutions.

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Soomro et al - 2026

DOI: http://doi.org/10.5281/zenodo.19706993

Conclusion

This study demonstrated that ultrasound predominates (70%) with mostly female patients, while MRI/CT cause disproportionate delays due to longer procedure and reporting times. Key delays stem from service time variability, uneven arrivals, and FIFO queue discipline. Recommendations include modality-specific scheduling, separate service channels, appointment systems, and digital reporting to improve efficiency.

Limitations of the Study

Single-center design and cross-sectional data limit generalizability and fail to capture seasonal or operational variability. Patient-reported measures introduced recall bias, and the absence of advanced queuing metrics or qualitative methods constrained analytical depth.

Future Research Recommendations

Advanced queuing simulations and multi-center studies across diverse healthcare settings are needed to improve generalizability and test interventions. International comparative research can identify best practices and low-cost strategies for resource-constrained environments.

REFERENCES

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387
Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.19706993

1. Basta YL, Tytgat KM, Klinkenbijl JH, Fockens P, Smets EM. Waiting time at a fast-track diagnostic clinic. Int J Health Care Qual Assur. 2016;29(5):523-35.
2. Aeenparast A, Farzadi F, Maftoon F. Waiting time for specialist consultation in Tehran. Arch Iran Med. 2012;15(12):756-8.
3. Dellaert N, Cayiroglu E, Jeunet J. Assessing and controlling the impact of hospital capacity planning on the waiting time. Int J Prod Res. 2015;54(8):2203-14.
4. Natarajan RN. Transferring best practices to healthcare: opportunities and challenges. TQM Mag. 2006;18(6):572-82.
5. Ozcan YA. Quantitative methods in health care management: techniques and applications. 1st ed. San Francisco (CA): Jossey-Bass; 2006.
6. Green LV. Queuing analysis in healthcare. In: Hall RW, editor. Patient flow: reducing delay in healthcare delivery. New York: Springer; 2006. p. 281-307.
7. Adele M, Barry S. Modelling patient flow in hospital using queuing theory. Unpublished manuscript; 2005.
8. Belciug S, Gorunescu F. Improving hospital bed occupancy and resource utilization through queuing modeling and evolutionary computation. J Biomed Inform. 2015;53:261-9. doi: 10.1016/j.jbi.2014.11.010
9. Komashie A, Mousavi A, Clarkson PJ, Young T. An integrated model of patient and staff satisfaction using queuing theory. IEEE J Transl Eng Health Med. 2015;3:1-11.
10. Green LV. Queuing analysis in healthcare. In: Stein DM, Hall RW, editors. Handbook of healthcare operations management. New York: Springer; 2021. p. 141-72.
11. Khan S, Ahmed M, Fatima N. Gender-based utilization patterns of diagnostic imaging services in Pakistan. Pak J Med Sci. 2020;36(5):987-92.

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387
Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.19706993

12. Smith J, Brown A, Taylor R. Gender differences in diagnostic imaging utilization: a population-based analysis. Radiology. 2021;299(3):567-75.
13. Ahmad M, Khan S, Ali R. Patient satisfaction and waiting time in outpatient radiology departments: a cross-sectional study from Pakistan. J Patient Exp. 2022;9(3):45-53.
14. Johnston R, Michel S. Three outcomes of service recovery: customer recovery, process recovery, and employee recovery. Int J Oper Prod Manage. 2020;40(2):79-99.
15. Gross D, Harris CM. Fundamentals of queuing theory. 5th ed. Hoboken (NJ): John Wiley & Sons; 2018.
16. Shortle JF, Thompson JM, Gross D, Harris CM. Fundamentals of queuing theory. 5th ed. Hoboken (NJ): John Wiley & Sons; 2018.
17. Lakshmi C, Iyer SA. Application of queuing theory in healthcare: a systematic literature review. Oper Res Health Care. 2020;25(3):100-15.
18. Hall RW. Patient flow: reducing delay in healthcare delivery. 2nd ed. New York: Springer Science & Business Media; 2019.
19. Cochran JK, Bharti A. A multi-stage stochastic methodology for designing hospital bed capacity. Eur J Oper Res. 2021;292(3):1023-37.
20. Zhang X, Li Y, Chen J. Optimizing patient flow in outpatient radiology: a simulation-based approach. Health Care Manag Sci. 2022;25(2):289-305.
21. Rahman M, Ahmed T, Islam S. Duration of patient stay in Bangladeshi tertiary hospital radiology departments. Bangladesh Med Res Counc Bull. 2021;47(2):89-96.
22. Kumar A, Singh P, Sharma R. Patient flow and waiting time analysis in Indian public hospital radiology departments. J Health Manage. 2020;22(4):512-27.
23. Boland GW, Duszak R, McGinty G. Report turnaround time: a critical quality metric in radiology practice. J Am Coll Radiol. 2021;18(2):245-52.

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.19706993

24. McDonald JS, Larson DW, Bruining DH. Factors affecting radiology report turnaround time: a comprehensive analysis. Acad Radiol. 2022;29(5):678-87.
25. Patel V, Desai M, Shah N. Delayed radiology reporting in Indian healthcare: prevalence, causes, and consequences. Indian J Radiol Imaging. 2021;31(2):234-42.
26. Hasan S, Rahman A, Chowdhury M. Reporting delays in advanced diagnostic imaging: a multicenter study across South Asian tertiary hospitals. J Med Imaging Radiat Sci. 2022;53(2):178-86.
27. Hopp WJ, Spearman MS. Factory physics: foundations of manufacturing management. 4th ed. Long Grove (IL): Waveland Press; 2021.
28. Farooq M, Ahmed S, Khan H. Patient counseling practices in Pakistani diagnostic centers: a multicenter evaluation. J Health Commun. 2022;27(4):289-98.
29. Cayirli T, Veral E. Outpatient scheduling in health care: a review of literature. Prod Oper Manage. 2019;28(4):819-37.
30. Gupta D, Denton B. Appointment scheduling in health care: challenges and opportunities. IIE Trans. 2020;42(11):800-19.
31. Raza A, Hussain M, Akhtar N. Quality of communication in Pakistani healthcare settings: patient perspectives. J Pak Med Assoc. 2021;71(8):1987-93.
32. Sharma V, Gupta R, Kumar P. Comparative analysis of waiting times in public and private sector radiology facilities in India. Indian J Public Health. 2021;65(3):245-52.
33. European Society of Radiology (ESR). Benchmarking report on radiology services across Europe: waiting times and report turnaround metrics. Insights Imaging. 2022;13(1):45-62.