

# Overview and classification of evaluation metrics of appointment scheduling systems

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## ABSTRACT

**Introduction:** This study reviews the several metrics used to evaluate the performance of appointment scheduling systems.

**Material and Methods:** The articles in English were searched using PubMed, Scopus, and Web of Science databases and Google scholar search engine until July 23, 2023. We used queueing theory to classify evaluation metrics.

**Results:** Out of 23403 articles, 75 papers were prepared for detailed analysis. We classify evaluation metrics of appointment scheduling system along with their definition and frequency of use. A total of 24 measures containing twelve (%50), seven (%29), and five (%21) were related to the categories of arrivals (patient), queue (at clinic), and server (physician) were found, respectively.

**Conclusion:** To the best of our knowledge, this paper was one of the first studies collecting and classifying all evaluation metrics of appointment scheduling system in order to help other researchers. Most metrics pertained to patients which may highlight the importance of the patient's perspective in evaluating appointment scheduling systems.

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## INTRODUCTION

The management of appointment scheduling systems is an important healthcare task. The process of appointment scheduling is the first unit in which the contact of patients begins with the health center and service providers [1-3]. Hence, this phase has a direct effect on the patient's perception and has a great impact on patient satisfaction [4-8]. Therefore, evaluating the appointment scheduling process can have beneficial outcomes such as increasing productivity, quality of care, and timely access [5, 9-12]. Several evaluation metrics measure the performance of appointment scheduling systems are in use, and we review them in this study. Despite the great attention to the domain of appointment scheduling systems, one lacks an overview of the common evaluation metrics of healthcare

appointment scheduling systems. In this paper, we review the metrics used in the literature and classify them based on terminology used in queueing theory.

## MATERIAL AND METHODS

The articles in English were searched based on the title and abstract keywords using PubMed, Scopus, and Web of Science databases and Google scholar search engine until July 23, 2023. Searching was completed by scanning bibliographies from selected articles. All papers on appointment scheduling systems were reviewed except for review articles, opinion and letters, operating room scheduling, and staff scheduling. The evaluation metrics were extracted from the selected articles and classified according to the common terminology used in queueing theory (Fig 1).

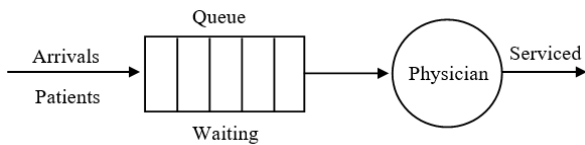


Fig 1: Queueing theory framework [13]

detailed analysis. Table 1 shows the classification of evaluation metrics of appointment scheduling system along with their definition and frequency of use. According to this classification, twelve metrics (%50), seven metrics (%29), and five metrics (%21) were related to the categories of arrivals (patient), queue (at clinic), and server (physician), respectively. The most widely used metrics in each category were patient waiting time (%41), no-show rate (%37), and doctor’s idle time (%12), respectively.

## RESULTS

Out of 23403 articles, 75 papers were prepared for

Table1: The classification of evaluation metrics of appointment scheduling systems

	Evaluation metrics	Definition	Frequency
Arrivals (Patient)	Patient no-show rate*	The number of no-shows divided by the sum of the number of no-shows and the total number of appointments kept [14]	28
	Patient satisfaction	Patient satisfaction related to appointment scheduling [4]	12
	Non-attendance rate	Cancellation rate plus no-show rate [15]	8
	Third next available appointment time	Amount of time between a patient’s request for an appointment and the third next available appointment for a routine visit [16]	7
	Patient continuity of care	The fraction of patients able to obtain appointments with their desired physician [17]	4
	Patient punctuality	The difference between a patient’s appointment time and actual arrival time [18]	3
	Access time	The number of days from request to appointment [19]	3
	Walk-in rate	The number of patients who walk in without appointments as a percentage of all appointments [18]	2
	Cancellation rate	The ratio of cancelled appointments to all appointments scheduled [20]	2
	Attendance rate	The ratio of patients attending their appointment at the originally scheduled time to all appointments scheduled [21]	2
	Patient tardiness	Difference between the scheduled time for the appointment and the time of the patients arrival [22]	1
	Proportion of active patients	Patient who had scheduled at least one appointment with the clinic over a 24-month period [23]	1
Queue (Clinic)	Patient waiting times	Subtract the greater of {appointment time, arrival time} from the service start-time [18]	31
	Clinic size (Patient Volume)	The number of patients scheduled per clinic session [18]	4
	Patient throughput	The number of patient arrivals in the clinic as well as the number of patients examined and released [24]	3
	Staff Satisfaction	Staff satisfaction related to appointment scheduling [25]	3
	Clinical staff cost	Total clinical staff salary divided by total number of visits [26]	2
	Acceptance rate	The ratio between the number of accepted appointments and the total number of appointment requests [27]	1
	Phone call volumes	All phone calls in the total clinic work time [28]	1
Server	Doctor’s idle time	Dividing total idle time in a session by the number of patients seen [18]	9
	Panel size (Visit Volume)	The number of patients covered by the physician [29]	7
	Service times	The amount of time the physician spends with the patient [30]	5
	Doctor’s overtime	Dividing total overtime {actual session end time minus scheduled end time} by the number of patients seen [18]	4
	Utilization rate	The provider’s actual service time divided by the total work time [27]	2

\* Patient no-show rate: equal to missed appointment rates [31]

## DISCUSSION

In this study, we classified the most common evaluation metrics of appointment scheduling systems using queueing theory terminology. Most metrics fell under in the arrivals (patient) category. A limitation of this study was that we did not investigate whether a reported metric in a study was

the most relevant one for the intended (clinical) use of the system.

## CONCLUSION

We provided a classification of evaluation metrics of appointment scheduling systems using queueing theory terminology. Most metrics pertained to patients which may highlight the importance of the

patient's perspective in evaluating appointment scheduling systems. The correspondence between metrics reported in the literature and their fitness for use merits future research.

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## AUTHOR'S CONTRIBUTION

All authors contributed to the literature review, design, data collection and analysis, drafting the manuscript, read and approved the final manuscript.

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