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SIMULATION-BASED ANALYSIS OF SLOT COMMUNICATION STRATEGIES FOR OUTPATIENT CLINICS

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ABSTRACT

Operational performance in clinics serving scheduled and walk-in patients depends not only on the scheduling policy but also on the "communicated slot" – the appointment time conveyed to patients. This study uses discrete-event simulation to evaluate the impact of different slot communication strategies on performance within a fixed-slot, split-pool appointment system. Six scenarios are analyzed by constructing communicated slots by offsetting the assigned slot by the mean patient arrival deviation and rounding to the nearest five or ten minutes. The analysis isolates the effects of these adjustments on performance metrics like scheduled and walk-in waiting time, length of stay, server utilization, and overtime. Results indicate that communicating the exact assigned slot yields the most balanced performance. Incorporating arrival offsets, especially with ten-minute rounding at high utilization, significantly degrades performance by increasing patient delays. However, five-minute rounding with or without an offset presents a viable alternative when rounding is an operational requirement.

1 INTRODUCTION

The literature on outpatient appointment scheduling has predominantly focused on optimizing slot allocation, sequencing, and overbooking rules (Cayirli and Veral 2009; Ahmadi-Javid et al. 2017). However, the construction of the communicated slot, the actual time conveyed to a patient, has received limited attention. This communicated slot can diverge from the internally assigned slot due to operational conveniences, such as rounding, or adjustments for habitual patient unpunctuality. This study examines how such different slot communication strategies influence performance in a clinic serving both scheduled and walk-in patients, while incorporating appointment carryovers, emergencies, and telemedicine disruptions. Specifically, this study investigates the effects of modifying the communicated slot via (i) an arrival-offset adjustment and (ii) rounding to the nearest 5 or 10 minutes.

2 METHODS

2.1 Model Overview

A discrete-event simulation model of a single-server outpatient clinic, based on the outpatient department of a tertiary care hospital in India, was developed using Python-salabim. The clinic operates for 300 minutes with 21 consultation slots of 14 minutes each. The clinic runs six days/week (five weekdays, one Saturday) and provides first and follow-up in-person and telemedicine consultations. Patients may arrive with or without prior appointments and are categorized as scheduled, walk-in, or emergency. Scheduled patients are pre-assigned to specific slots. Walk-ins and emergencies arrive randomly during operating hours.

A split-pool policy partitions the total daily slots into a scheduled pool ($N = T - W*$) and a walk-in pool ($W* = \lfloor p \cdot T \rfloor$), where p is the target walk-in proportion and T is the total number of slots. Priority rules follow the order: Emergency > Carryover > Scheduled > Walk-in. Unserved scheduled patients are carried over to the next day, while unserved walk-ins exit the system (walkaways).

Patient arrivals are non-stationary. Arrivals for scheduled patients are modeled using a normal distribution with a random offset from their communicated time, and walk-in arrivals are modeled according to a Poisson process. Consultation durations are sampled from fitted empirical distributions. The model also incorporates probabilistic telemedicine disruptions, which can extend or terminate a consultation depending on the disruption duration.

2.2 Communicated Slot Scenarios

Communicated slot is constructed by modifying the assigned slot start time (t_a) by: (i) optionally shifting t_a by the mean arrival offset (μ_v: weekday = -0.875 min; Saturday = -8.33 min) and (ii) optionally rounding to the nearest 5 or 10 minutes. These modifications yield the following six slot communication scenarios:

S1: Communicated slot = t_a: no offset, no rounding

S2a: Communicated slot = round(t_a, 5): Nearest 5-minute rounding (no offset)

S2b: Communicated slot = round(t_a, 10): Nearest 10-minute rounding (no offset)

S3: Communicated slot = $t_a - \mu_v$: Offset by mean unpunctuality (no rounding)

S4a: Communicated slot = round($t_a - \mu_v$, 5): Offset + Nearest 5-minute rounding

S4b: Communicated slot = round($t_a - \mu_v$, 10): Offset + Nearest 10-minute rounding

The model was run for 30 replications over a 42-day period, with a 12-day warm-up, to evaluate the performance metrics.

3 RESULTS

The baseline scenario (S1), which communicates the exact scheduled slot, yielded the best overall outcomes for scheduled patients with a mean waiting time and length of stay (LOS) of 6.7 and 19.3 minutes, respectively. Introducing rounding alone (S2a, S2b) increased delays modestly, particularly under 10-minute rounding. Offset-only communication (S3) significantly increased scheduled waiting time to approximately 19.3 minutes and raised server utilization to nearly 0.998. Scenarios combining offset with rounding (S4a, S4b) performed the worst. Specifically, S4b (offset with 10-minute rounding) resulted in the highest server utilization (≈1.027) and the longest walk-in LOS (≈77.96 minutes). Across all scenarios, walk-in patients see limited benefit from these adjustments, and server overtime remained stable at approximately 21-22 minutes.

4 CONCLUSION

This simulation study demonstrates that slot communication strategies have a measurable impact on outpatient clinic performance, particularly in high-utilization settings (≈0.95). While adjustments for early arrivals via offsets can reduce initial server idle time, they lead to increased queueing and significant delays under high server utilization. Communicating the exact, unadjusted appointment time provides the most robust and balanced performance. If rounding is an operational necessity, rounding to the nearest 5 minutes presents a viable alternative. In contrast, coarse rounding intervals (e.g., 10 minutes), especially when combined with an offset, significantly degrade patient and server outcomes.

These findings highlight that outpatient systems must carefully align their slot communication strategies with their operational goals, particularly in high-utilization settings with mixed demand. As this study shows, seemingly minor adjustments can substantially influence patient flow, server performance, and service quality.

REFERENCES

Ahmadi-Javid, A., Z. Jalali, and K. J. Klassen. 2017. “Outpatient Appointment Systems in Healthcare: A Review of Optimization Studies”. European Journal of Operational Research 258(1):3–34.

Cayirli, T., and E. Veral. 2009. “Outpatient Scheduling in Health Care: A Review of Literature”. Production and Operations Management 12(4):519–549.