Proceedings of the 11th North American International Conference on Industrial Engineering and Operations Management, Milwaukee, Wisconsin, USA, June 9-11, 2026

Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA
Published: June 9, 2026
DOI: 10.46254/NA11.20260153

A Greedy First-Fit Heuristic for Reallocating Outpatient Surgeries from Main OR to Ambulatory Surgery Center

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Abstract

Operating room (OR) is among the most capital-intensive resources in health systems, yet inefficiencies persist in allocating outpatient surgery across facility types. Although ambulatory surgery centers (ASCs) are optimized for lower-acuity procedures, many eligible cases remain scheduled in higher-cost main hospital ORs, consuming prime-time capacity needed for emergent, complex, or inpatient surgeries and contributing to access delays. This study proposes a greedy first-fit scheduling heuristic to identify outpatient surgical cases eligible for transfer from the main OR and assign them to available ASC OR time slots. The approach is evaluated retrospectively using ten months of fiscal year 2025 EHR-derived surgical data from a pediatric health system with eight main ORs and four ASC ORs. Across the study period, the algorithm identified 2,071 movable outpatient cases and reassigned each without creating scheduling conflicts. Simulated reallocation increased aggregate ASC block utilization from 50.2% to 73.1% across the four ASC rooms, with room-level gains of 18.1–30.8%. These findings demonstrate that the proposed heuristic can serve as a prospective decision-support tool for optimizing surgical case allocation between the main OR and ASC. The algorithm is currently being used prospectively to support future scheduling decisions.

Keywords
OR utilization, Ambulatory Surgery Center, Surgery Scheduling, Heuristic

1. Introduction
Operating room (OR) represents one of the most capital- and labor-intensive resources in any hospital, and its efficient utilization directly affects both clinical throughput and financial performance (Macario, 2010). Health systems are increasingly challenged to deliver surgical care amid constrained OR capacity, rising labor costs, and growing pressure to improve access and financial sustainability. Within this this context, optimizing the allocation of surgical cases between main OR and ambulatory surgery centers (ASC) represents a critical and underutilized lever.

ASCs are designed to deliver lower-acuity outpatient procedures in a streamlined, cost-effective environment. ASCs typically feature shorter turnover times, leaner staffing models, and lower overhead compared with main hospital ORs, making them well suited for elective outpatient cases (Munnich & Parente, 2014). Despite these advantages, a substantial proportion of outpatient surgical volume continues to be performed in higher-cost main OR settings. This misalignment is often driven by legacy scheduling patterns, block allocation inertia, surgeon preference, and the lack of systematic tools to identify reallocation opportunities. The consequences of this misalignment are twofold. First, the main OR becomes congested with cases that could be performed in a lower-cost ambulatory setting, consuming prime-time capacity that is better reserved for higher-acuity, resource-intensive procedures, including inpatient surgeries, emergent cases, and procedures requiring specialized equipment and perioperative support. Second, ASC rooms may sit underutilized during weekday prime time, representing a missed opportunity to absorb outpatient volume and improve both access and throughput.

The OR scheduling literature has addressed a broad range of optimization problems, including block scheduling (Blake & Donald, 2002), case sequencing and assignment (Cardoen et al., 2010), turnover time reduction, and demand forecasting (Denton et al., 2007). Guerriero and Guido (2011) provided a comprehensive survey of operational research applications in OR management, highlighting the growth of mathematical programming, heuristics, and simulation-based approaches for improving OR performance. It is noted that optimization efforts address within-facility scheduling rather than cross-facility allocation decisions. More recent reviews confirm continued methodological progress, including addressing uncertainty, operational constraints, and implementation considerations in real hospital settings (Al Amin et al., 2024; Harris & Claudio, 2022; Zhu et al., 2019). In parallel, recent optimization studies have advanced dynamic and multi-objective OR planning approaches, including workload balancing, patient prioritization, and proactive-reactive scheduling strategies (Akbarzadeh & Maenhout, 2024; Aringhieri et al., 2022; Gökalp et al., 2023).

The ASC literature provides a strong economic and operational rationale for site-of-care reallocation. Prior studies have shown that many outpatient procedures can be performed more efficiently in ASCs than in hospital-based settings, often with lower costs and comparable outcomes for appropriately selected patients (McCormick et al., 2025; Munnich & Parente, 2014; Rana et al., 2025; Wang et al., 2022). However, these studies primarily establish the value of ASC care at an aggregate level. They do not address the operational question faced by perioperative teams on a daily basis: which specific cases currently scheduled in the main OR can be moved to the ASC, and where can they be placed in the ASC schedule without creating conflicts?

This paper addresses that operational gap by proposing a greedy first-fit scheduling heuristic that identifies outpatient surgical cases scheduled in the main OR that are clinically eligible for ASC care and assigns them to feasible ASC room-time slots while respecting ASC operating hours, existing schedules, and turnover buffers. The algorithm produces case-level, room-specific, and time-specific reassignment recommendations, making it directly usable for prospective scheduling decisions. Furthermore, the contribution of this work is not only to quantify underused ASC capacity, but to provide a practical and reproducible computational approach for reallocating surgical volume from the main OR to the ASC in real-world perioperative operations.

1.1. Objectives

The primary objective of this study is to develop and evaluate a practical scheduling algorithm for reallocating clinically eligible outpatient surgical cases from the main OR to ASC OR. More specifically, this work focuses on three objectives: first, to design and implement a case-level greedy first-fit heuristic that identifies eligible outpatient cases in the main OR and assigns them to feasible ASC room-time slots while respecting operational constraints; second, to apply the algorithm to both retrospective and prospective EHR surgical schedules in order to demonstrate its feasibility and real-world usability as a decision-support tool; and third, to quantify the operational impact of the proposed reallocation through changes in ASC block utilization.

2. Study Setting and Data

This study was conducted in a pediatric health system with a surgical suite comprising 12 ORs across two facility types. The main OR suite consists of eight rooms that operate seven days per week, including weekends, and accommodate the full spectrum of surgical acuity, including inpatient, emergent, and complex outpatient procedures.

The ASC consists of four rooms that operate on weekdays only within a defined window of 7:00 AM to 3:00 PM and are intended for lower-acuity outpatient procedures with same-day discharge.

Case-level surgical data were extracted from the enterprise data warehouse (EDW) for all procedures performed between October 1, 2024, and July 31, 2025. Each record represented a single surgical case and included the following fields: Surgery Date, OR Location, OR Room, OR Service (surgical specialty), Wheels-In Time, Wheels-Out Time, Patient Class, and Case Duration in minutes. Records with missing values for any of the three critical timestamp fields (Surgery Date, Wheels-In Time, or Wheels-Out Time) were excluded, and no imputation was performed. Cases with non-positive computed durations were excluded from the reallocation algorithm but retained in utilization analyses to preserve baseline schedule characterization. To support identification of reallocation candidates, the multi-category Patient Class variable was transformed into a binary classification: Outpatient Surgery (for cases labeled as outpatient surgery in the source system) and Other (for all remaining classes, including inpatient, observation, emergency, and related designations).

Because not all outpatient cases performed in the main OR are clinically appropriate for the ASC environment, clinical exclusion criteria were applied before algorithm execution. These criteria were defined in consultation with perioperative leadership to reflect institutional clinical practice. Cases were excluded from reallocation candidacy if (i) the surgical specialty required resources or monitoring capabilities available only in the main OR (e.g., Cardiology, Cardiovascular Surgery, Neurosurgery, Cardiac Anesthesiology), (ii) the patient's age or body mass index fell outside institutionally defined ambulatory eligibility thresholds, or (iii) the patient's medical history included conditions associated with elevated perioperative risk in an ambulatory setting (e.g., significant cardiopulmonary comorbidity, history of malignant hyperthermia, or anticipated postoperative intensive care needs). Cases meeting any exclusion criterion were retained in baseline utilization analyses but removed from the candidate set used by the reallocation algorithm.

3. Methods

This study proposes a scheduling heuristic that identifies eligible outpatient cases currently assigned to the main OR and proposes a feasible reassignment to an available time slot in an ASC room without introducing scheduling conflicts. This section formalizes the problem, describes the algorithm, and presents the pseudocode.

3.1 Problem Formulation

Let S denote the full set of surgical cases and let $S^{cand} \subseteq S$ denote the candidate set, defined as all cases satisfying four conditions: (i) Patient Class equals Outpatient Surgery; (ii) the assigned room is one of the eight main OR rooms (R1 through R8); (iii) the surgery date falls on a weekday; and (iv) the case does not meet any of the clinical exclusion criteria defined in Section 2. Let R^{asc} = {r1, r2, r3, r4} denote the set of ASC rooms. The ASC operating window is defined by a start time T_s = 07:00 AM and an end time T_e = 03:00 PM. For each candidate s ∈ S^{cand}, let $d(s)$ denote its duration (in minutes) computed as WheelsOut(s) − WheelsIn(s) in minutes. For each ASC room $r \in R^{asc}$ and date t, Let $\varepsilon(r,t)$ denote the set of existing surgeries in room r on date t, and let $\mathcal{P}(r,t)$ denote the set of previously proposed assignments to room r on date t accumulated during algorithm execution. The objective is to maximize the number of reassigned cases (i.e., maximize the cardinality of the feasible assignment set), subject to the following constraints:

(C1) Operating window constraint: The proposed start time t_{start} must satisfy $t_{start} \geq T_s$, and the proposed end time $t_{end} = t_{start} + d(s)$ must satisfy $t_{end} \leq T_e$.
(C2) Non-overlap constraint: The proposed interval $[t_{start}, t_{end})$ must not intersect any interval in the combined schedule $\mathcal{E}(r,t) \cup \mathcal{P}(r,t)$.
(C3) Turnover buffer constraint: A minimum turnover buffer $\beta = 15$ minutes must be preserved before the proposed start time, relative to the end of the immediately preceding case in the same room-day schedule (or relative to T_s if the case is first in the day).

3.2 Outpatient Surgery Reallocation Algorithm

We propose a greedy first-fit scheduling heuristic with cumulative conflict tracking to reallocate outpatient cases from the main OR to the ASC. The algorithm processes candidate cases sequentially in dataset order. For each candidate case s ∈ S^{cand} scheduled on date t with duration $d(s)$ the algorithm searches for a feasible placement across ASC rooms in a fixed order (r1, r2, r3, r4). For a given room r, the algorithm constructs a composite room–day schedule by merging the set of existing scheduled cases $\mathcal{E}(r,t)$ with the set of previously accepted reassignments $\mathcal{P}(r,t)$, and sorting all intervals by start time. A time cursor is initialized to the ASC start time T_s. The algorithm scans each inter-case gap, including the gap before the first case and after the last case, to determine whether the available gap can accommodate the candidate while maintaining a turnover buffer β. Specifically, a gap is feasible if it allows a start time $t_{start} = curser + \beta$ and end time $t_{end} = t_{start} + d(s)$ that satisfies $t_{end} \leq T_e$. When a feasible gap is found, the assignment is accepted and recorded, and the proposed interval is immediately appended to $\mathcal{P}(r,t)$. This cumulative update ensures that subsequent assignments are checked against both the original schedule and all previously proposed moves, preventing double-booking by construction. The algorithm then proceeds to the next candidate. If no feasible slot exists in any ASC room, the candidate is skipped and not reassigned. The pseudocode formalizing this procedure is presented below.

Algorithm 1 Greedy First-Fit Outpatient Reallocation

```
Input:
    𝒮: Complete surgical dataset
    R_ASC: Ordered list of ASC rooms [r_1, r_2, r_3, r_4]
    R_Main: Main OR rooms [R_1, R_2, ..., R_8]
    T_s, T_e: ASC operating window start and end times (07:30, 15:30)
    β: Turnover buffer (15 minutes)
Output:
    ℳ: Set of accepted reassignments, formatted as (s, r, t_start, t_end)
Step 1: Initialization
ℳ ← ∅
Initialize 𝒫(r, t) ← ∅ for all r ∈ R_ASC and dates t
Step 2: Candidate Selection
S^cand ← {s ∈ 𝒮 | s.PatientClass = "Outpatient" ∧ s.OR_Room ∈ R_Main
           ∧ IsWeekday(s.Date) ∧ s.Duration > 0 ∧ ¬ExcludedClinically(s)}
Step 3: Execution
for each s ∈ S^cand do
    t ← s.Date
    d_s ← s.Duration
    assigned ← FALSE
    for each r ∈ R_ASC do
        if assigned = TRUE then break
        end if
        ℰ_{r,t} ← Intervals of existing scheduled surgeries in (r, t)
        ℐ ← SortByStartTime(ℰ_{r,t} ∪ 𝒫(r, t))
        t_cursor ← T_s
        for i ← 0 to |ℐ| do
            if i < |ℐ| then
                gap_end ← ℐ[i].t_start
            else
                gap_end ← T_e
            end if
            t_start ← t_cursor + β
            t_end ← t_start + d_s
            if t_end ≤ gap_end and t_end ≤ T_e then
                ℳ ← ℳ ∪ {(s, r, t_start, t_end)}
                𝒫(r, t) ← 𝒫(r, t) ∪ {(t_start, t_end)}
                assigned ← TRUE
                break
            end if
            if i < |ℐ| then
                t_cursor ← ℐ[i].t_end
            end if
        end for
    end for
end for
return ℳ
```

The time complexity of the algorithm is $O(n \cdot |R_{asc}| \cdot k)$, where n = $|S^{cand}|$ is the number of candidate cases and k is the maximum number of cases scheduled in any single room on any single day. Because the algorithm processes candidates in dataset order and assigns each to the first feasible slot encountered, the solution is order-dependent and not globally optimal. That is, an earlier candidate may consume a slot that would have better accommodated a later, longer-duration case. Despite this theoretical limitation, the greedy first-fit approach offers several practical advantages that favor operational deployment. Its cumulative conflict-tracking mechanism, updating $\mathcal{P}(r, t)$ after each accepted assignment, reliably prevents double-booking and guarantees schedule feasibility. The algorithm executes in 10 minutes on the full ten-month dataset, making it well suited for environments where interpretability, speed, and ease of integration with existing workflows are valued over theoretical optimality. The fixed room ordering (r1 is tried first) introduces a bias toward lower-index rooms; alternative strategies such as round-robin or load-balanced ordering could yield more evenly distributed assignments and represent avenues for future refinement.

After generating proposed moves, reassigned cases are appended to the original ASC schedule to form a combined post-reallocation dataset. Each case is labeled as either Original (already scheduled in the ASC) or Moved (proposed reallocation from the main OR), enabling both visual and quantitative comparison of schedule density before and after the intervention.

ASC block utilization is computed before and after reallocation at both the room and aggregate levels. Utilization is defined as the proportion of available prime-time minutes occupied by scheduled cases, where available minutes equal 480 minutes per weekday within the 07:00 AM–3:00 PM operating window. Utilization is computed from the union of scheduled case intervals within each room–day. All analyses were implemented in Python (pandas, NumPy, matplotlib) and structured as a reproducible pipeline that can be rerun on future data extracts.

4. Results and Discussion

4.1 Baseline Block Utilization

Baseline utilization was evaluated across all 12 rooms over the 10-month study period using Gantt-timeline charts, where each row represents a calendar day and each case is plotted from Wheels-In to Wheels-Out. Figure 1 shows a representative month (October 2024) for four main OR rooms. Weekday schedules were densely packed during prime-time hours, with many rooms exhibiting near-continuous case coverage. Weekend activity was less frequent and concentrated in a subset of rooms, consistent with urgent and emergent demand. Importantly, outpatient cases were interspersed throughout the main OR schedules, indicating that outpatient volume regularly consumes prime-time main OR capacity alongside higher-acuity cases.

Figure 2 displays the corresponding baseline schedules for ASC rooms (weekdays only). ASC utilization varied substantially by day and room: some days showed tightly sequenced cases, whereas others contained sizable idle periods, particularly during mid-day windows. The ASC case mix was dominated by a small number of specialties, most notably ENT, Ophthalmology, Oral Surgery, and Gastroenterology, which is consistent with procedures commonly routed to ambulatory settings. Collectively, these baseline patterns motivate the reallocation problem addressed in this study: outpatient cases remain scheduled in the main OR while measurable capacity exists in the ASC.

4.2 Reallocation Algorithm Output

Across the full 10-month period, the algorithm identified 2,071 (out of 5320) eligible outpatient cases in the main OR that could be reassigned to ASC rooms without creating scheduling conflicts. When combined with the 3,935 cases originally scheduled in the ASC, the post-reallocation schedule contained 6,006 total ASC cases. The distribution of proposed moves aligned with clinical expectations: ENT contributed the largest share of reassigned volume, reflecting the prevalence of short-duration outpatient ENT procedures in the main OR. Additional reallocation volume came from General Surgery, Orthopedics, Gastroenterology, Urology, Ophthalmology, and Plastics. Because the heuristic searches rooms in a fixed order, assignments were modestly skewed toward lower-index ASC rooms (with r1 receiving the largest share). The imposed 15-minute turnover buffer helped preserve operational realism by preventing infeasible back-to-back scheduling.

Figure 3 shows the post-reallocation ASC schedules for October 2024, where original ASC cases are indicated by diagonal hatching and algorithm-moved cases are shown with solid fill. Relative to the baseline schedules (Figure 2), the ASC rooms exhibit visibly higher scheduling density, particularly on days that previously contained substantial mid-day gaps. No overlapping intervals are observed within any room-day, confirming that the cumulative conflict-tracking mechanism prevented double-booking. Despite these gains, residual idle periods remain in several rooms, suggesting that additional volume could be accommodated under expanded eligibility criteria or alternative scheduling policies.

4.3 Impact on ASC Block Utilization

To quantify how much ASC capacity could be absorbed through reallocation, utilization is computed for each ASC room before and after applying the proposed case moves. Table 1 presents room-level results for October 2024 as a representative month, and Table 2 summarizes the aggregate results by room over the full ten-month study period.

As shown in Table 1, baseline ASC utilization in October 2024 ranged from 42.7% (r4) to 56.4% (r2), with an overall utilization of 49.6%, indicating substantial unused prime-time capacity. After applying the reallocation algorithm, utilization increased between 73.2% and 78.6% across the four rooms, representing gains of 21.2% to 32.7%. The overall utilization rose to 76.2%, a 26.6% improvement. Notably, r4, which had the lowest baseline utilization, exhibited the largest improvement (+32.7%). This is consistent with the expectation that rooms with the greatest available capacity absorb proportionally more incremental volume under a first-fit heuristic.

Table 1**.** ASC Utilization for October 2024 Before and After Reallocation

Room	**Wkdays**	**Avail (min)**	**Occ. Before**	**Util. Before**	**Occ. After**	**Util. After**	**Δ**
r1	23	11,040	5,773	52.3%	8,682	78.6%	+26.3%
r2	23	11,040	6,230	56.4%	8,569	77.6%	+21.2%
r3	23	11,040	5,181	46.9%	8,077	73.2%	+26.3%
r4	23	11,040	4,718	42.7%	8,321	75.4%	+32.7%
Overall	23	44,160	21,902	49.6%	33,649	76.2%	+26.6%

These improvements persisted over the full study period (Table 2). Baseline utilization ranged from 39.1% (r4) to 59.7% (r1). After reallocation, all rooms achieved utilization between 69.9% and 78.1%, representing increases of 18.1–30.8 percentage points.

Table 2 confirms that these findings generalize beyond a single month. Over the full ten-month study period, baseline ASC utilization ranged from 39.1% (r4) to 59.7% (r1). After reallocation, all four rooms achieved utilization between 69.9% and 78.1%, representing gains of 18.1% to 30.8%. As in the October example, the largest gains occurred in rooms with the greatest baseline idle capacity, with r4 again showing the largest absolute improvement (+30.8%).

Table 2. ASC Utilization Over the Full Study Period (Oct 2024–Jul 2025)

Room	**Avail (min)**	**Occ. Before**	**Util. Before**	**Occ. After**	**Util. After**	**Δ**
r1	104,640	62,522	59.7%	81,738	78.1%	+18.4%
r2	104,640	57,634	55.1%	76,559	73.2%	+18.1%
r3	104,640	48,920	46.8%	74,249	71.0%	+24.2%
r4	104,640	40,894	39.1%	73,099	69.9%	+30.8%

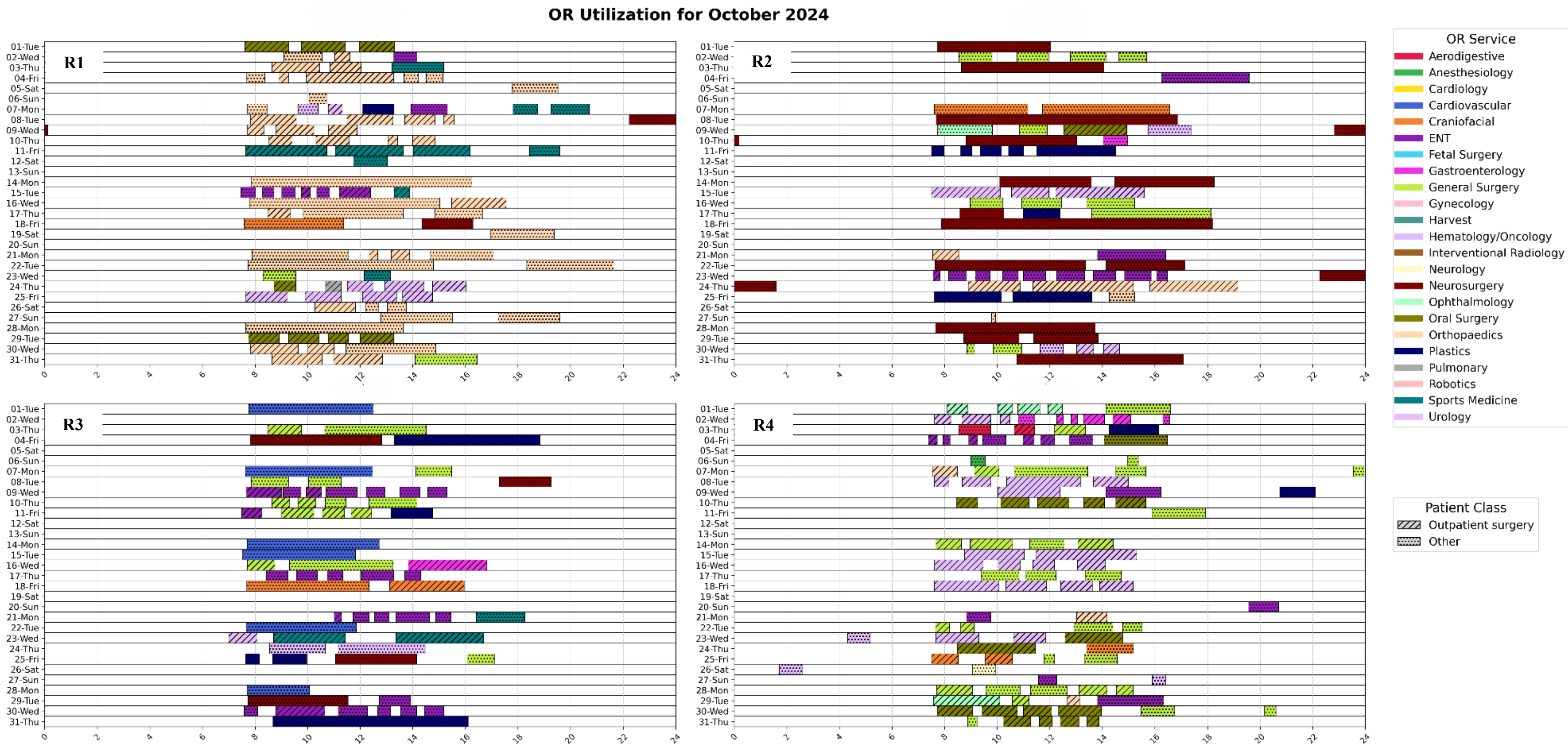

Figure 1. Block utilization chart for main ORs (R1 - R4), October 2024

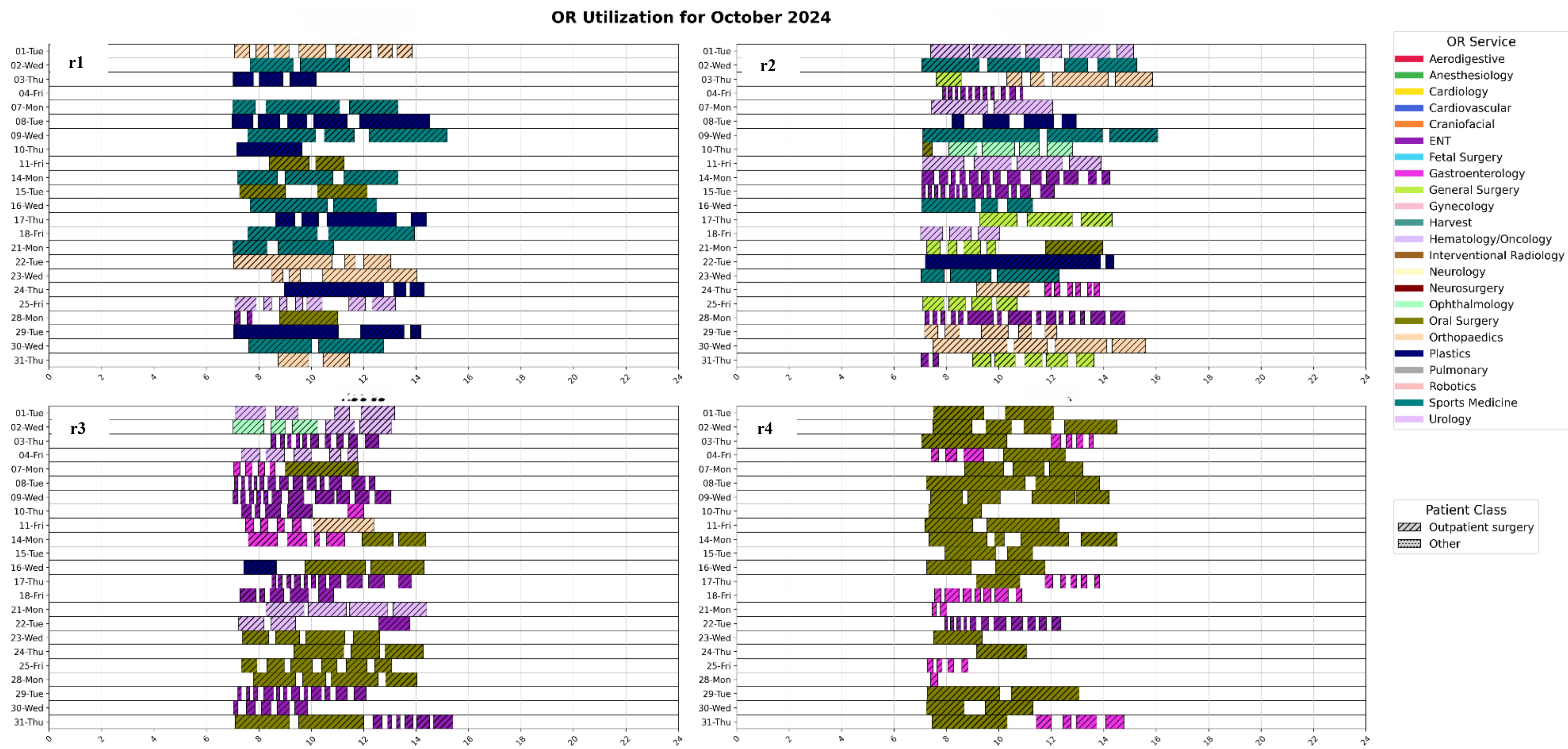

Figure 2. Block utilization chart for ASC ORs (r1 – r4), October 2024

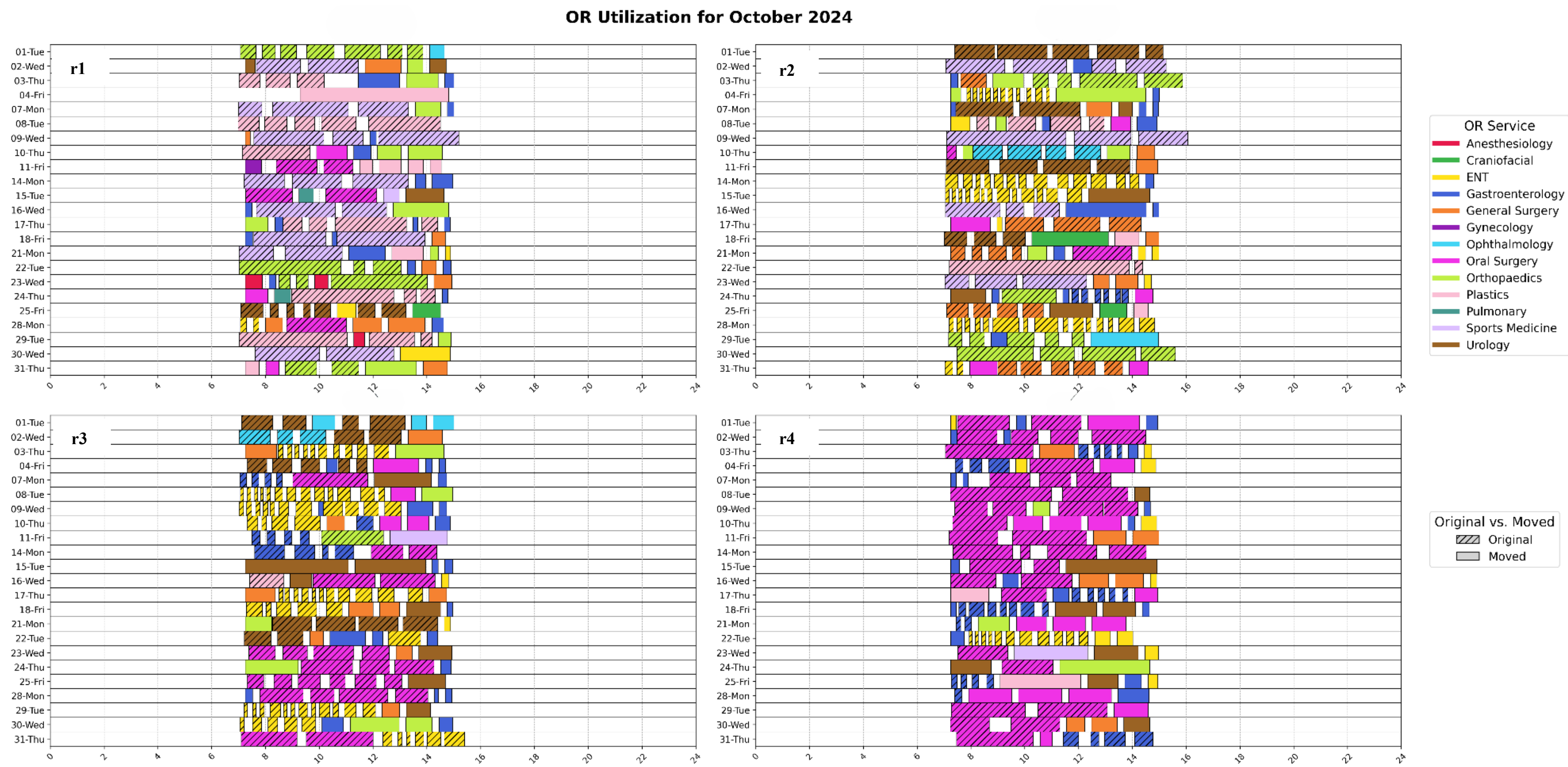

Figure 3. Post-reallocation block utilization for ASC rooms (r1 – r4), October 2024

4.4 Operational Implications

These results show that a simple, clinically grounded heuristic applied to EHR schedules can identify actionable opportunities to shift outpatient cases from the main OR to the ASC. The utilization gains (e.g., +26.6% in October 2024 and +18–31% across rooms over the full study period) indicate substantial ASC capacity to absorb volume currently performed in the main OR. Reallocating these cases frees prime-time main OR capacity for higher-acuity and urgent procedures, improving access without additional infrastructure, while increasing ASC throughput and improving per-case economics.

Importantly, the approach supports prospective use. Because upcoming schedules are available in the EHR (typically 1–2 weeks in advance), the algorithm is run on future schedules to generate feasible reassignment recommendations and implement approved moves before the day of surgery, enabling ongoing site-of-care optimization.

5. Conclusion

This paper presented a data-driven framework for site-of-care optimization that reallocates clinically eligible outpatient cases from the main OR to available ASC time slots using a greedy first-fit heuristic with cumulative conflict tracking. Applied to 10 months of EHR-derived surgical schedules, the algorithm identified 2,071 (out of 5320) movable cases and reassigned each without scheduling conflicts. Overall ASC block utilization increased from 50.2% to 73.1% across the study period (49.6% to 76.2% in October 2024), with room-level gains of 18.1–30.8%. Importantly, the approach is designed for prospective execution on upcoming schedules, supporting proactive perioperative capacity management.

Several limitations should be noted. First, because the heuristic is greedy, its performance may depend on the order in which cases are evaluated. Future work should examine alternative case-ordering rules, such as sorting cases by duration or surgical service, to assess the robustness of the approach. Second, the heuristic does not guarantee optimality; therefore, future studies should compare its performance with exact or advanced optimization methods, such as integer linear programming, to estimate the optimality gap. Third, the current analysis assumes fixed operational conditions, including ASC hours and turnover buffers. Future work should incorporate more dynamic constraints, such as variable turnover times, staffing availability, surgeon block schedules, cancellations, and add-on cases.

Finally, this study was conducted within a single health system over a ten-month period. Broader validation across multiple hospitals, surgical specialties, ASC configurations, and health system settings is needed to assess generalizability and scalability. Future research should also include prospective validation to evaluate how the heuristic performs when integrated into routine scheduling workflows and to measure its operational, financial, and clinical impact over time.

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