Optimizing Patient Flow and Utilization: A Data-Driven Analysis of Hospital Overcrowding

Jason F. Berger [1], Aidan C. Sobocinski [1], Andrew L. Burnter [1], Patrick B. Fox [1], Jackson E. Kiland [1], Rupa S. Valdez[2,*]
[*] *Rupa S. Valdez: rsv9d@virginia.edu*

[1] *Systems and Information Engineering Department*
University of Virginia
Charlottesville, United States

[2] *Systems and Information Engineering Department and Public Health Department*
University of Virginia
Charlottesville, United States

***Abstract*— The goal in healthcare is to deliver the right care, to the right patient, at the right time, in the right place, and by the right people to ensure optimal patient outcomes. Inefficiencies or delays in patient flow can undermine this goal, leading to increased lengths of stay, reduced patient satisfaction, and unnecessary strain on the hospital. Post-surgical observation represents a critical phase in which patients are monitored closely for complications while needing to be efficiently transitioned towards discharge. Post-surgical observation has been identified as an area of interest, with opportunities for improvement to speed up the discharge transition without compromising care quality. This work is aimed at analyzing patient flow and operational processes associated with post-surgical observation care, with an emphasis on intake, bed placement, and discharge workflows. The objective is to identify systemic factors that hold back efficient use of post-surgical observation areas and address them using a mixed-method approach. Quantitative analysis of historical and current operational data following the summer 2025 reorganization provides insight into patient volumes, lengths of stay, and resource utilization. This analysis focuses on procedures and departments associated with longer-than-expected stays, as well as outliers with unusually long stays or potential data entry issues. Additionally, qualitative interviews and direct observations of staff involved in perioperative care, bed placement, and unit management were conducted to capture contextual factors, identify pain points, and develop potential solutions. A short survey was also used to leverage hospital staff experience to refine and evaluate potential solutions. Results include identifying key operational bottlenecks, decision constraints, and communication breakdowns, as well as developing targeted recommendations to improve patient classification and placement, data quality and availability, and communication of placement options. A secondary outcome of the study was the development of tailored data collection strategies to support future monitoring and improvement efforts.**

Keywords—healthcare, patient flow, systems approach, optimization, hospital overcrowding, post-surgical care

I. Introduction

Hospital overcrowding has become a persistent problem across U.S. hospitals [1]. This issue stems from increasing pressures, including rising patient demand, limited inpatient capacity, and inefficient patient movement within the hospital system [2]. Hospitals face challenges from surging patient volumes and a lack of capacity to flex accordingly [3]. As a result, patient flow is one of the most frequently studied contributors to overcrowding [1]. The hospital patient flow system is broken into three areas: patient admission, internal patient flow, and patient discharge [1], [4]. When any of the three areas experience a patient bottleneck, the entire system becomes overcrowded [1]. Overcrowding results in a variety of negative outcomes, including longer wait times, lower-quality care, lower patient satisfaction, and worse health outcomes for admitted patients [1], [5].

By focusing on a specific component of patient movement, health administrators isolate internal patient flow as an area for improved hospital operations under their control. According to a 2025 study, a discrete-event simulation identified inefficient bed allocation as a driver of patient flow delays [6]. When the simulation was adjusted to allow cross-departmental bed sharing, thereby enabling more efficient allocation, the length of patient stay decreased significantly [6]. As a result of studies such as this one, hospitals have direct control over patient flow while patients remain in the system.

One specific piece of this system is the Operating Room (OR). In a hospital, ORs include preoperative areas (pre-op), the operating rooms, and post-anesthesia care units (PACUs). The standard progression for a low-risk patient is as follows: prepare in the pre-operative rooms, receive surgical care in the operating room, recover in a PACU bed for fewer than 12 hours, and be discharged from the hospital. However, this flow may be disrupted if the pre-operative areas and operating rooms throughput more patients than the number of PACU beds available. As a result, many hospital systems have implemented surgical observation units [2]. These units provide post-anesthesia care.

More broadly, hospitals nationwide are pursuing various interventions to alleviate overcrowding. According to a 2024 study, multifaceted approaches are more effective than single interventions [7]. The approaches recommended for covering all three areas of hospital patient flow are: triage optimization and AI-based tools that model patient acuity and offer decision-making support; dynamic staffing models that adjust staffing

based on real-time patient flow data rather than fixed schedules; lean process improvements like eliminating waste and streamlining workflows; point-of-care testing by expanding diagnostic capabilities at the bedside and using telehealth for triage. Implementing one of these approaches would be less effective than implementing all of them together [7].

While the literature provides thorough guidance on ED-level interventions, there is a notable gap in research addressing the operational decision-making processes that determine how post-surgical observation units are utilized. Specifically, factors such as clarity of placement criteria, communication pathways, decision-making authority, data accessibility, and whether clinically appropriate patients are placed in observation beds remain understudied. This study addresses that gap by analyzing patient flow and operational processes associated with post-surgical observation care, with an emphasis on intake, bed placement, and discharge workflows. By combining quantitative analysis of operational data, qualitative interviews, and direct observation, the study aims to identify systemic bottlenecks, constraints, and communication barriers and to develop targeted recommendations to improve utilization.

II. Methods

This project aimed to aid in quality improvement at a Mid-Atlantic teaching hospital. The hospital had identified overcrowding and potential inefficiencies in patient flow and wanted a third party to work with their internal teams to analyze the situation and identify potential areas for improvement. Mixed methods were used sequentially to scope the problem, identify pain points, highlight areas for improvement, and evaluate potential solutions.

A. Analysis of Electronic Heath Record Data

The hospital provided two data sets from the Electronic Health Record (EHR). The first data set covered the Surgical Observation Unit from July through October 2025. This data set contained 593 patient encounters coming from 17 different surgical teams. The second data set covered a unified pre- and post-operative unit volumes for October 2025, containing 799 records. Key variables from these data sets included patients' class, admission and discharge dates, encounter duration in hours/ length of stay, primary provider team, and service type. Data were first checked for outliers and potential entry errors or omissions using the interquartile range method, where values exceeding 1.5 times the IQR above Q3 or below Q1 are flagged. These checks included identifying values that could not be true (such as negative encounter durations), values that significantly exceeded other data points, and values that exceeded what hospital staff indicated to be typical for these short-stay units. 100 hours was used as a threshold in part due to its significance in data entry, since it would require adding an extra digit over the expected maximum of two-digit times. Data were analyzed using Minitab, primarily using boxplot statistics to compare different categories of patients and procedures. Additional data requests around topics such as patient flows and more specific tracking of patient stays by areas and procedure were made throughout the project, but many of these requests could not be fulfilled for reasons that will be discussed below.

Also provided with the EHR data was a patient progression metric review. The review contained graphs detailing metrics such as lengths of stay, readmissions, total discharges, discharge times, total admissions, and department admissions for some of the units assessed in this project. Not all the information contained was directly relevant to this project, but it was reviewed to provide additional context and show work already in progress at the hospital, and to avoid wasteful duplication.

B. Observations

In-person observations at the hospital were conducted on two occasions, once by the full team of five and once by a two-person team. The first full team observation, lasting approximately three hours, was facilitated by various hospital staff, including an administrator. This first observation was oriented toward gaining familiarity with the layout and meeting key actors within the system. It also aimed to identify potential inefficiencies for further investigation and candidates for interviews. The second observation was shadowing an anesthesiologist for four hours, with the goal of gaining a more complete understanding of patient flow immediately around and during a surgical procedure. It also sought to capture how data is recorded and to identify potential issues and opportunities for improvement. During observations, field notes were taken by hand in notebooks or electronically. Each entry captured the time of note, category/location, and the observation itself.

C. Interviews

Semi-structured virtual interviews with hospital staff identified earlier were used to gain additional insights into work at the bed center, operating room, and post-surgical care placement options. Four interviews were conducted, with interviewees consisting of a bed center head, a bed center assistant, a surgeon, and a post-operative care unit director. Interviewees were asked about their position, typical workday, responsibilities, pain points, bottlenecks, work allocation, disruptions due to capacity issues, and potential solutions. Interviews lasted just over 20 minutes on average and were recorded and transcribed for further analysis. Each transcript was reviewed for pain points and suggestions, and then they were compared to the other interviews and observations to identify commonalities.

D. Recommendations

By triangulating data from EHRs, observations, and interviews, gaps in patient classification, placement familiarity, and data availability were identified as potential targets for solutions. Ideas from staff, this team, and literature were combined to develop preliminary solutions. These preliminary solutions were refined internally and through short unstructured meetings and/or email with hospital staff, consisting of systems operations and post-operative unit leadership.

E. Survey

As the project progressed and potential solutions to problems were identified and refined, an anonymous survey was conducted. The survey was sent to those who had previously been shadowed or interviewed, and they were asked to fill it out and pass it to their teams and any other colleagues that they thought might be able to provide additional insights.

This survey was designed to leverage the experience and knowledge of hospital staff to evaluate and improve each of the potential solutions that were formulated after the interviews. Respondents were asked to identify their role at the hospital. For each of the six potential solutions, the survey asked the respondent to rate it on a five-point Likert scale for "How impactful would this be?" and for "How feasible is this to implement?". Lastly, respondents were asked to rank each of the six potential solutions for overall value and provided with the opportunity to give a free-text response with any additional feedback or comments they had. These data were analyzed using medians of responses for both impact and feasibility for each of the six potential solutions.

III. Results

A. Analysis of Electronic Health Data

Through boxplot analysis of encounter duration at a post-operation observation unit, 19 outliers were revealed within the inpatient class. As shown in Fig. 1, inpatient encounters had a median duration of 51.8 hours, but the minimum encounter duration was 11.6 hours compared to the maximum of 686.8 hours. Using the interquartile range method, 19 of 200 inpatient encounters (9.5%) fell outside the upper boundary of 141.4 hours, with 27 encounters exceeding 100 hours and 11 exceeding 200 hours. This analysis demonstrates that a small number of long-stay patients skew the distribution of encounters. The second data set also included data quality issues, where 2 records were flagged as likely data entry errors due to their negative length of stay values. Across all 593 encounters in the Surgical Observation Unit dataset, 7.4% were identified as outliers, while the remaining 92.6% fell within the expected range, but the concentration of extreme values within the inpatient class skews the overall distribution.

During the analysis of the metric review, the encounters of the Surgical Observation Unit volume categorized by the surgical teams that placed the patients are shown in Table I. As seen in Table I, Urology was the highest-volume team with 227 encounters, representing 38.5% of all Surgical Observation Unit visits.

When combined with Bariatrics/ Minimally Invasive and Interventional Radiology, these three groups accounted for 68.5% of the total of the Surgical Observation Unit volume, with the remaining 14 teams (Gynecology; Oncology; Emergency General Surgery & Trauma; Plastics; Gynecology;

Table I. Encounters by Team

Primary Team	Volume of Surgical Observation Encounters by Team				
	Jul	*Aug*	*Sep*	*Oct*	*Total*
Urology	53	50	62	59	224
Bariatrics/ Minimally Invasive	22	19	24	22	87
Interventional Radiology	12	23	22	27	84
Other 14 groups	37	45	40	65	187
Total	124	137	148	173	582

a. Table from Health Metric Review

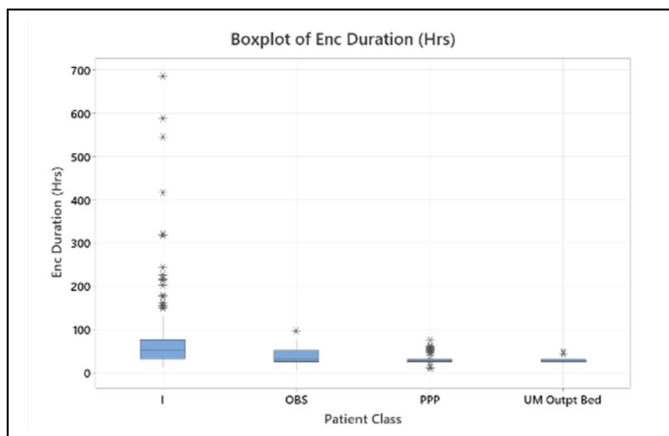

Fig. 1. Patient Encounter Duration of a Post-Operation Observation Unit

Ear, Nose, and Throat; Medicine; Colorectal; Endocrine; Urology Gynecology; Breast & Melanoma; Hepatobiliary; Orthopedics; Transplant; and data from non-classified teams) splitting the other 31.5%. This concentration of volume indicates that these 3 teams assign more patients to this unit for post-surgery observation compared to the other surgery groups due to both a higher patient volume and higher assignment rates to the unit.

B. Analysis of Observations

Through observations, patients were noted to move through various post-surgical pathways based on anticipated length of stay and acuity, ranging from short-term PACU recovery to extended observation or admission to specialized floors. Observations revealed variability in how different units were utilized in practice. Areas such as PACU and extended care were often repurposed to help balance shifting demands and patient volume in the hospital.

Across these observations, several key insights emerged. Despite certain areas, such as pediatric units, experiencing overall system strain, there appeared to be an underutilization in observation spaces like the Surgical Observation Unit. Additionally, provider preference and familiarity with specific recovery units influenced patient placement decisions, which sometimes overrode intended workflows. This behavior is consistent with the interview findings, suggesting system-wide inconsistencies in patient classification and unit utilization. Spaces such as PACU and pre-operative areas are being adapted to fulfill extended care needs, demonstrating a high level of flexibility within the system. Although this adaptability supports short-term capacity management, it unintentionally contributes to the growing variability in patient placement and the resulting inefficiencies in overall patient flow.

C. Analysis of Interview Data

A primary theme identified across interviews was a lack of consistency in patient classification and placement decisions. Decisions are frequently made on a case-by-case basis, with limited standardized criteria guiding placement into units such as PACU and the Surgical Observation Unit. This variability creates confusion and contributes to inefficient use of capacity. Several interviewees mentioned uncertainty around both

placement logic and decision ownership. One stakeholder noted, "I've been asking that question… and I've never gotten an answer," when referring to who determines patient placement, illustrating the absence of clear responsibility. Conflicting stakeholder priorities further complicate decisions, as surgeons, unit leadership, and capacity management may each advocate for different outcomes. In some cases, clinically appropriate patients are not placed in observation units due to provider preference, leading to underutilization of spaces such as the Surgical Observation Unit.

A second theme identified across the interviews was the lack of structured data collection to monitor patient flow and operational performance. Though placement decisions and patient movement occur continuously throughout the system, limited action is taken to consistently track these actions, including reclassification, utilization patterns, and missed placement opportunities. As a result, stakeholders rely on experience-based judgment rather than objective data when evaluating system performance. As one interviewee noted, "it's all anecdotal," highlighting the absence of standardized tracking. This shortage of structured data collection inhibits the ability to identify recurring inefficiencies and implement data-driven improvements. Without a concrete method of capturing and analyzing patient flow data, inefficiencies remain difficult to quantify and address.

A third theme across the interviews was the limited accessibility and usability of data within the system. While stakeholders acknowledge that relevant data exists within hospital systems, it is often difficult to access, delayed, or not presented in a way that supports operational decision-making. This absence of visibility forces stakeholders to rely on fragmented and manual communication methods, rather than the shared system-wide tools. As one interviewee mentioned, "[Electronic Health Record] has all the data we ever need. We just need a data analyst to put it together," illustrating the gap between data availability and its usability. As a result, even when data is technically available, it is not effectively utilized to improve coordination or patient flow.

Collectively, these findings highlight that inefficiencies in patient flow are driven not only by capacity constraints but also by inconsistencies in patient classification, gaps in data collection, and limited system visibility.

D. Solutions

As a result of the triangulation of results from electronic health records, observations, and interviews, several potential areas were identified as candidates for improvement. Each of the solutions falls into one of three broad areas: patient categorization and placement, staff knowledge of placement options, and data infrastructure. Table II shows each of the six potential solutions that were considered, along with a brief description.

Table II. Potential Solutions

Solution	Description
S1 (Categorize)	Standardized patient classification scale
S2 (Knowledge)	Visual patient placement reference
S3 (Knowledge)	Patient placement training
S4 (Data)	Data tracking improvements (ex. outlier flagging)
S5 (Data)	Data availability improvements (ex. response speed)
S6 (Categorize)	Dedicated inpatient unit instead of pooled beds

Solution 1 encompasses creating and using a numeric scale to represent the overall level of care and duration of stay required by a patient after surgery, and matching those numbers to the unit(s) best equipped to provide that in typical cases of that level. That will allow them to make a preliminary determination based on the procedure and risk factors of the patients for what level of care they will likely need. This could also include a reference to help providers decide where patients of a given level should generally be placed. This will improve prediction accuracy and reduce the amount of reshuffling that the Bed Center must perform.

Solution 2 is for a simple and short placement visual reference, such as a flowchart or map, to ease the cognitive load for surgeons and ensure all placement options are given due consideration. This reference would be made available and posted where staff can easily reference it, as well as potentially being added to existing patient placement tools that need more information. The reference would need to be short, as the goal is to reduce the cognitive load, and a complex document would likely be ignored. The creation of this reference sheet should include input from the inpatient units where patients may be placed, to ensure their roles are communicated clearly. It should also include the bed center and the surgeons themselves, since they best know what factors are commonly important to their decision-making and should be highlighted. The design of the reference must be centered on how it will be used on a day-to-day basis by hospital staff and designed to aid them in that efficiently.

Solution 3 is a short training course for staff that goes over the current patient placement options (to be repeated if there are major changes in the future). It would be designed to bring the entire staff onto the same page. It would also be an option for bringing new surgeons (or other staff) up to speed on what their options will be, to ensure that everyone has a shared understanding of how patients should be placed.

Solution 4 is to implement automated flagging into EHR systems to alert staff if they are inputting values that do not make sense or if patients are staying longer than is considered reasonable (which would need to be determined on a per-unit basis). This will allow for correction if the entry is in error, improving the quality of data and thus the quality of future decisions made from it. It can also enhance tracking of patients who truly do have long stays, focusing care on patients who may have unusual circumstances that require extended time in the unit, and allowing for patterns to be noticed that may indicate problems with typically used classifications for patients.

Solution 5 is improvements to data request tools and response speeds to allow for more data-driven responses to perceived problems. This should also be applied to external teams, as those teams are operating outside the normal organization of the hospital and, as such, are at even greater risk

of requests being lost or not answered in a timely manner. Responses should aim to either provide the data quickly or, if this is not possible, inform the requester and explain if the problem is due to time, rules, availability, and/or other factors.

Solution 6 is a larger scale and thus longer-term change to a dedicated inpatient unit instead of various pooled beds. This would eliminate complexity and reduce the need for surgeons to pick between various similar units.

E. Survey Analysis

The analysis of the survey is largely dependent on the sample size. At the time of writing, the available sample (n=3) is insufficient for meaningful statistical analysis; however, a preliminary look at the results available is still presented here. The question regarding position has been omitted for confidentiality. Table III (below) shows medians for impact and feasibility for all six solution options. They have both been re-coded to simple numerical values (1-5), where higher is better (stronger impact and easier to implement). As shown, most options have a median of 4 for impact (high impact) and 2 for feasibility (difficult). S6, however, has a better impact (5) than most, while S1 has a worse impact (3). The final ranking question showed agreement that a change to a dedicated inpatient unit (S6) would be most valuable, followed by data tracking improvements (S4). There was also agreement that the least valuable solutions were the classification scale (S1) and visual placement reference (S2), with S3 and S5 landing in the middle. There were no responses to the free-response question. Considering the extremely limited data available, in this team's view, it is not appropriate to firmly reject (or choose) specific solutions based on this survey data at the time of writing.

TABLE III. SURVEY MEDIANS

Solution	Impact (higher is better)	Feasibility (higher is better)
S1	3	3
S2	4	3
S3	4	2
S4	4	2
S5	4	2
S6	5	2

IV. DISCUSSION

In talking with hospital staff, they expressed a desire for a more developed classification system that gives a clear decision process and more objective classification as a guideline (while still allowing for nuance and deviation when, in the judgment of the practitioner, it is needed). There are already some efforts at the hospital to develop more standardized guidelines for where patients should go, and these efforts should continue. The current system has a variety of options for post-operative care, and this complexity allows for flexibility but makes it difficult to track and manage. Surgeons are asked to place their patients after surgery, but currently this is done mostly from whatever they know about the options, and as shown above, this can be limited and dictated largely by habit. The reference sheet would primarily help practitioners who already know the options and simply need a reminder, but it may not be the best way of building that knowledge the first time. The training would ensure they have this initial knowledge to be reminded of. High-quality data will be needed when making these standardized systems and materials, and yet that data is useless if it cannot be easily accessed when needed and trusted when it is accessed. Not only could data entry and data request process improvements ensure timely access to accurate data that does exist, but they could also provide quicker feedback when required data does not exist. Lastly, the idea of a dedicated inpatient unit instead of various pooled beds was floated by hospital staff, which would reduce fragmentation and complexity.

The introduction of this paper identifies a notable gap in the literature: while existing research provides thorough guidance on ED-level interventions, there is limited work addressing the decision-making processes that determine how post-surgical observation units are utilized. The findings of this study directly address clarity of placement criteria, communication pathways, decision-making authority, and data accessibility, to confirm that the gap is not only present in the literature but actively experienced by hospital staff.

Interview findings reveal that patient placement decisions are made on a case-by-case basis with limited standardization, and that a draft of the patient placement tool at the study site had not been formally implemented or widely circulated. This extends the work of Wang et al. [6], who demonstrated that inefficient bed allocation drives patient flow delays at the department level. Communication breakdowns compound this problem: interviews and observations revealed that many surgeons were unaware of the Surgical Observation Unit's intended purpose or target population, consistent with Mostafa and El-Atawi's [7] emphasis that clear communication is a prerequisite for any operational intervention to succeed. Similarly, no clear decision-making authority for patient placement was identified, with surgeons, the bed center, and unit leadership each exercising influence without a defined hierarchy. Existing literature documents the negative outcomes of inefficient flow [1], [4], [5] but does not examine how this ambiguity in authority contributes to underutilization in post-surgical settings.

Data accessibility and quality emerged as a particularly notable barrier. Stakeholders consistently expressed a belief that the hospital's electronic health record contains the data needed for operational decisions. However, the quantitative analysis conducted in this study revealed substantial data quality issues, such as encounter durations reaching nearly 687 hours and records with negative length-of-stay values. This indicates that the gap between perceived data availability and actual data reliability is significant. This tension has not been documented in the literature for observation units, and without reliable data, the data-driven decision-making recommended across the literature [6], [7] cannot be effectively implemented.

The six solutions proposed by this study, including classification (S1, S6), staff knowledge (S2, S3), and data infrastructure (S4, S5), take a multifaceted approach, consistent with Mostafa and El-Atawi's [7] finding that combined strategies outperform single interventions. However, the solutions proposed here differ from those in the existing

literature, which tends to focus on ED-specific challenges such as rapid triage, point-of-care testing, and AI-based acuity modeling [3], [7]. Post-surgical observation units face a distinct set of challenges, ensuring that known, stable patients are routed to the correct recovery environment through clear criteria, informed staff, and accessible data. This study contributes to the literature by demonstrating that many of the systemic issues documented in ED settings, such as fragmented decision-making, communication breakdowns, and data gaps, also exist in post-surgical observation, where they had not previously been systematically examined.

V. Conclusion

This team worked with a Mid-Atlantic teaching hospital to help identify and solve pain points related to overcrowding in post-operative care and discharge. Several potential areas for improvement were identified in patient classification, staff knowledge, and data systems. Six potential solutions have been created to address them and preliminarily evaluated. Limitations include direct hospital work being limited only to a single hospital and insufficient survey data to strongly evaluate solutions. Limitations also include limited data and potential data inaccuracy issues for the analysis of EHR data, some of which were identified and recommendations made, but none have been implemented at the time of writing. Further work by the hospital should include more development and evaluation of those solutions. The survey used to evaluate the solutions should be updated with more complete solutions and re-run with a larger sample size to improve confidence. Data improvements should be made where possible, and then findings re-evaluated with higher confidence data. The hospital should also look at how potential solutions may be tailored to complement long-term hospital plans and projections in other areas.

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