Received: 5 May 2022 | Revised: 11 June 2022 | Accepted: 27 June 2022

DOI: 10.1002/emp2.12784

JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN
A GLOBAL JOURNAL OF EMERGENCY MEDICINE
Open Access
WILEY

ORIGINAL RESEARCH

The Practice of Emergency Medicine

The effect of batched patient–physician assignment on patient length of stay in the emergency department

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Funding and support: By *JACEP Open* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist.

Abstract

Objectives: Queuing theory suggests that signing up for multiple patients at once (batching) can negatively affect patients' length of stay (LOS). At academic centers, resident assignment adds a second layer to this effect. In this study, we measured the rate of batched patient assignment by resident physicians, examined the effect on patient in-room LOS, and surveyed residents on underlying drivers and perceptions of batching.

Methods: This was a retrospective study of discharged patients from August 1, 2020 to October 27, 2020, supplemented with survey data conducted at a large, urban, academic hospital with an emergency medicine training program in which residents self-assign to patients. Time stamps were extracted from the electronic health record and a definition of batching was set based on findings of a published time and motion study.

Results: A total of 3794 patients were seen by 28 residents and ultimately discharged during the study period. Overall, residents batched 23.7% of patients, with a greater rate of batching associated with increasing resident seniority and during the first hour of resident shifts. In-room LOS for batched assignment patients was 15.9 minutes longer than single assignment patients (P value < 0.01). Residents' predictions of their rates of batching closely approximated actual rates; however, they underestimated the effect of batching on LOS.

Conclusions: Emergency residents often batch patients during signup with negative consequences to LOS. Moreover, residents significantly underestimate this negative effect.

KEYWORDS
administration, batching, operations, provider assignment, throughput

Supervising Editor: Christian Tomaszewski, MD, MS.

1 | INTRODUCTION

1.1 | Background

Over the past 5 years, US emergency departments (EDs) have faced increasing patient volumes and lengthening wait times, resulting in worsening crowding.[1,2] Addressing ED crowding is central to improving ED operations.[3–5] The input-throughput-output conceptual model of crowding provides a practical framework to characterize drivers of ED crowding.[6] The output component, driven predominantly by inpatient boarding, is the most frequently cited reason for ED crowding.[7–9] However, the throughput component, focused on internal efficiency and effectiveness, is most amenable to ED-driven interventions. Many approaches exist to improve throughput and reduce patient length of stay (LOS) with varying degrees of resource cost.[10] With the goal of finding ways to improve patient LOS without significant cost, this study examines how the mechanics of patient assignment may influence LOS.

Existing research suggests that methods of patient–physician assignment can affect ED workflow. Several models for assignment exist, including independent self-assignment (ad libitum) and rotational assignment.[11] Although most EDs rely on some form of self-assignment, some EDs have experimented with automated rotational assignment systems and realized improved LOS, reduced rates of patients leaving without being seen, and improved quality of resident education.[12,13] Under a system of self-assignment, certain behaviors that have been extensively evaluated in the business and operations literature have been shown to negatively affect workflow, including foot dragging (holding up patient dispositions to avoid taking new patients), social loafing (waiting for other physicians to take patients from a queue when working in teams or before shift changes), and cherry picking/selection bias.[14–17]

In systems of self-assignment, physicians can choose to sign up for multiple patients at once (batching) or a single patient at a time. Figure 1 illustrates these alternatives. Queuing theory suggests batching patients should negatively affect LOS.[18] For example, assume there are two patients (A and B) to be seen in a shared queue and two physicians are on shift. If one physician immediately signs up for both patients, the second physician is idle and his/her capacity is wasted. In addition, patient B must wait until after the physician has seen patient A. If this physician is interrupted before seeing patient B, this patient's wait time may increase considerably.

1.2 | Importance

Literature suggests flow time (LOS) and throughput both increase with batch size but that flow time increases at a faster rate than throughput.[19] To our knowledge, there are no published data quantifying resident–patient assignment batching and its effect on ED patient LOS.

The Bottom Line

Emergency department resident physicians often likely to batch patients, especially early in their shift. This retrospective review of 3794 patient encounters showed an almost 16-minute increased length of stay in batched vs singly assigned patients, which was an effect underestimated by the physicians.

1.3 | Goals of this investigation

In this study, we aimed to (1) quantify the rate of batching in resident–patient assignment, (2) determine the effect of batched assignment on in-room LOS, and (3) characterize residents' perceptions of batched assignment.

2 | METHODS

2.1 | Study design

We performed a retrospective, observational study to evaluate the effect of resident–patient assignment batching on patient in-room LOS in the ED. This study was undertaken as a quality improvement project and did not examine protected health information. As such, the institutional review board determined this study was exempt from requiring formal review.

2.2 | Study setting and population

We conducted this study in the ED of a single, large, academic, tertiary care, level I trauma center located in the Midwest. The institution has an emergency medicine residency with 28 residents at the time of the study (10 postgraduate year 1 [PGY1], 10 PGY2, 8 PGY3). In addition to being staffed by emergency residents, the ED was to a lesser extent staffed by internal medicine, family medicine, anesthesia, and plastic surgery residents. Senior residents do not supervise junior residents. All residents check out patients directly to attending physicians. The ED employed a system of self-assignment for resident-patient signup. A "next to see" list on the electronic health record (EHR) displayed available roomed patients for resident assignment. No system constraint limited assignment behavior, though department policy directed residents to select patients based primarily on acuity and secondarily on LOS. No restriction or guidance had been given regarding resident–patient assignment batching, including for junior emergency or off-service residents. Residents staffed all patients with an attending physician (after self-assignment) and saw a majority of the ED patient

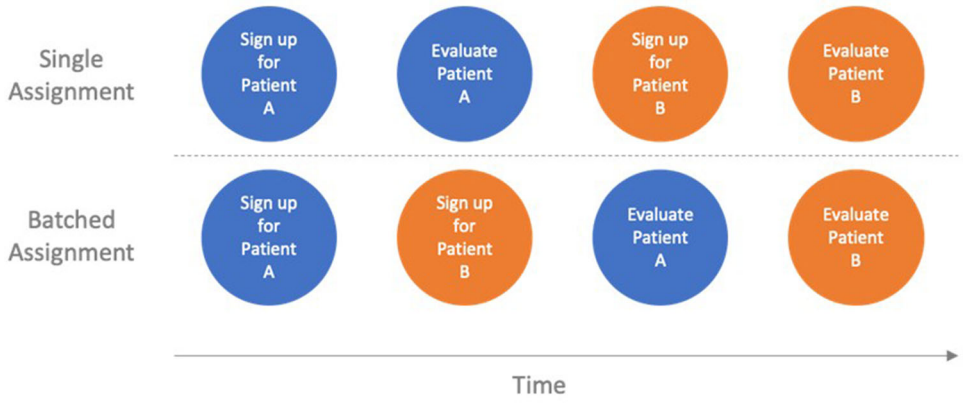

FIGURE 1 Illustration of batching versus single signup in patient assignment

volume. A minority of patients were seen by attendings alone or by nurse practitioners with or without an attending.

We included all discharged patients seen by a resident physician in the ED from August 1, 2020 to October 27, 2020. The decision to focus on discharged patients was driven by (1) significant variability in in-room LOS for admitted patients because of hospital crowding and ED boarding and (2) inability to capture comparable disposition decision times for both admitted and discharged patients.

2.3 | Measurements

We developed a data set of patient encounters meeting inclusion criteria via a query of the hospital EHR (Epic, Epic Systems Corporation, Verona, WI). Variables collected included times of patient arrival, patient rooming, resident assignment, and patient departure. Additional variables included patient demographics, patient chief complaint, and resident category (ie, emergency medicine PGY1–3, off service). Off-service residents of all specialties and years of training were grouped for the purpose of this study because the number of these residents is significantly fewer than emergency residents and the primary aim of this study was to examine emergency resident batching behavior. Two (or more) patients assigned to the same resident within 4 minutes (inclusive) were all considered batched, and those greater than 4 minutes were considered single. This definition was applied independent of ultimate disposition. For example, assume a resident signs up for Patient A at 0700 and Patient B at 0703. After workup, Patient A is admitted and Patient B is discharged. Patient B would be in our data set and considered a batched assignment. In the literature, there is no generally accepted time cutoff to define a batched group of patients. A Radio Frequency Identification (RFID)-enabled time and motion study at an urban, academic ED in the Northeast demonstrated an average attending time per visit of 7.7 minutes and an average number of in-room encounters per visit of 2.[20] Based on these findings, we set the batching definition at 4 minutes (7.7 minutes divided by 2, rounded up). In the results section, we present a sensitivity analysis of our primary outcome variable to this batching definition. We also present results associated with cutoffs of 2, 3, 5, and 6 minutes.

To supplement patient encounter data, we collected emergency resident perceptions regarding patient assignment batching via an anonymous online survey. Table 1 lists questions included in the survey. We collected data on resident category (PGY1–3) but no other identifying information. We asked residents to estimate their batching rate. To aggregate results from this question, we used bin midpoints to calculate specific rates. We asked residents to hypothesize why their peers choose to batch during patient assignment, as well as to indicate why they do so themselves. To answer these questions, residents were asked to force rank a predetermined list of 8 reasons. Finally, residents were asked to predict the effect of batching on patient LOS.

2.4 | Outcomes

The primary variables of interest were rates of assignment batching and patient in-room LOS.

2.5 | Data analysis

Data management and statistical analyses were performed using SAS software (version 9.4) (Copyright (c) 2002–2012 by SAS Institute Inc., Cary, NC, USA. All Rights Reserved). Categorical variables were summarized with percentages and continuous variables were summarized by means and standard deviation. The chi-square test was used to make global comparisons of categorical variables across groups. *T* test was used to make global comparisons of the means across the groups. Two-sided *P* values less than 0.05 were considered statistically significant.

3 | RESULTS

3.1 | Characteristics of study subjects

Between August 1, 2020 and October 27, 2020, 3930 patients were seen by residents and ultimately discharged from the ED. Initial

TABLE 1 Resident survey questions

Question	Potential responses
1. PGY level?	• PGY1 • PGY2 • PGY3
2. Do you sign up for multiple patients at once?	• Yes • No
3. What percentage of your total patient volume are those you sign up for multiple-at-a-time?	• 0%–10% • 10%–20% … • 90%–100%
4. Why do you think your resident colleagues sign up for multiple patients at once? (force rank) 5. Why do you sign up for multiple patients at once? (force rank)	• Economy of motion—seeing multiple patients while up from workstation • Economy of scribe/interpreter usage—seeing multiple patients with a scribe/interpreter • Many patients to be seen—long physician next to see list • Beginning of shift - desire to see multiple patients when your census is 0 • Compensate for co-resident(s)—other residents not able to keep up pace • Competition—need to claim patients to match or keep up with resident peer(s) • Improved ED flow—batching patients shortens their LOS • Cherry picking—pick up a less desirable patients to get to an interesting chief complaint
6. What impact do you think signing up for multiple patients at once has on patient length of stay?	• Significant positive impact (>30 min shorter LOS for "multiples") • Moderate positive impact (5–30 min shorter LOS for "multiples") • Negligible positive impact (<5 min shorter LOS for "multiples") • No Impact • Negligible negative impact (<5 min longer LOS for "multiples") • Moderate negative impact (5–30 min longer LOS for "multiples") • Significant negative impact (>30 min longer LOS for "multiples")

Abbreviations: ED, emergency department; LOS, length of stay; PGY, postgraduate year.

analysis of in-room LOS demonstrated a positively skewed distribution. The long right tail included encounters with in-room LOS greater than 6000 minutes (100 hours). Chart review of a sample of these encounters suggested most were psychiatric patients. At the institution in this study, a subset of psychiatric patients is found to require inpatient psychiatric care, but owing to inpatient psychiatric capacity constraints, they board in the ED while awaiting definitive care. These patients are seen and managed by psychiatry and can board in the ED for days before an appropriate disposition can be made, which often includes discharge from the ED to either an inpatient psychiatric facility (technically a transfer but may appear in EHR as a discharge) or home because their acute psychiatric condition has been stabilized. To normalize this data, the long tail was truncated above 675 minutes based on a frequency histogram. Clinically, the in-room LOS for these patients is so long that no realistic correlation with patient assignment behavior would be material. We truncated 136 patient encounters, 3.5% of total encounters, in this process. The remaining 3794 patient encounters were included in our analysis.

A total of 3794 patient encounters were included in our analysis. Table 2 describes characteristics of these patients.

The mean age, percentage of males, and mean assignment hour were similar for the 2 groups. Our analysis demonstrated a small but statistically significant difference in emergency severity index (ESI) between the 2 groups. The rate of patients staffed by senior emergency residents, defined as PGY2 or PGY3 emergency residents, was 86.3% for batched patients compared to 63.6% for single patients.

In March 2021, an electronic survey link was emailed to the 28 current emergency residents. The survey was live from March 13, 2021 to March 24, 2021. Twenty-two residents completed the survey, a 79% response rate. PGY1, PGY2, and PGY3 response rates were 90%, 80%, and 63%, respectively.

3.2 | Batching rate and survey results

The overall resident–patient assignment batching rate was 23.7% across all resident types. Senior emergency residents (PGY2 or PGY3) batched at the highest rate; emergency interns and off-service residents batched at a significantly lower rate. Table 3 details specific batching rates by resident category.

In-room LOS averaged 299.6 minutes for batched assignment patients and 283.7 minutes for single assignment patients, a statistically significant difference of 15.9 minutes. Table 4 demonstrates the sensitivity of batched assignment rate and in-room LOS to changes in batching definition. As described in the Section 2, our base case assumes patients were batched if assigned within 4 minutes (inclusive) of each other based on an RFID-based time and motion study. A frequency histogram of interpatient assignment times demonstrated a large difference between 2 and 3 minutes. As such, in this sensitivity analysis, we included additional cases with batched assignment defined as within 2, 3, 5, and 6 minutes (inclusive).

Resident predictions of batched assignment rates closely approximate actual rates. PGY1 and PGY2 residents slightly underpredicted

TABLE 2 Patient characteristics

Characteristic	Single assignment n = 2895	Batched assignment n = 899	*P* value
Mean age, years (SD)	44.5 (18.5)	45.2 (19.5)	0.32
Male sex, %	48.2	46.4	0.34
Mean emergency severity index (ESI), %			
ESI 1	0.5	0.2	
ESI 2	53.6	48.8	
ESI 3	40.0	43.5	0.03
ESI 4	5.5	6.5	
ESI 5	0.5	1.0	
Staffed by senior emergency residents, %	63.6	86.3	<0.01
Mean resident assignment hour (SD)	12.1 (6.6)	12.2 (6.7)	0.68
Top 10 triage chief complaints, frequency (% of total)			
Abdominal pain	210 (7.3%)	76 (8.5%)	
Chest pain	214 (7.4%)	63 (7.0%)	
Fall	108 (3.7%)	25 (2.8%)	
Other	80 (2.8%)	53 (5.9%)	
Shortness of breath	101 (3.5%)	26 (2.9%)	
Motor vehicle crash	100 (3.5%)	22 (2.4%)	
Back pain	77 (2.7%)	21 (2.3%)	
Headache	69 (2.4%)	28 (3.1%)	
Flank pain	58 (2.0%)	13 (1.4%)	
Leg pain	50 (1.7%)	16 (1.8%)	
Top 10 total	1,067 (36.9%)	343 (38.2%)	

TABLE 3 Rates of batching by resident category

Resident category	Batched assignment rate	*P* value
Off-Service	8.3%	<0.01
PGY1	11.5%	<0.01
PGY2	29.7%	<0.01
PGY3	29.6%	<0.01

Abbreviation: PGY, postgraduate year.

TABLE 4 Sensitivity of in-room length of stay to batching definition

Batching definition	Batched assignment #, %	Average In-room length of stay difference (batched—single), minutes	In-room length of stay difference *P* value
< = 2 minutes	783, 20.6%	18.2	<0.01
< = 3 minutes	881, 23.2%	15.8	<0.01
< = 4 minutes (base case)	899, 23.7%	15.9	<0.01
< = 5 minutes	969, 25.5%	14.9	<0.01
< = 6 minutes	1023, 27.0%	14.7	<0.01

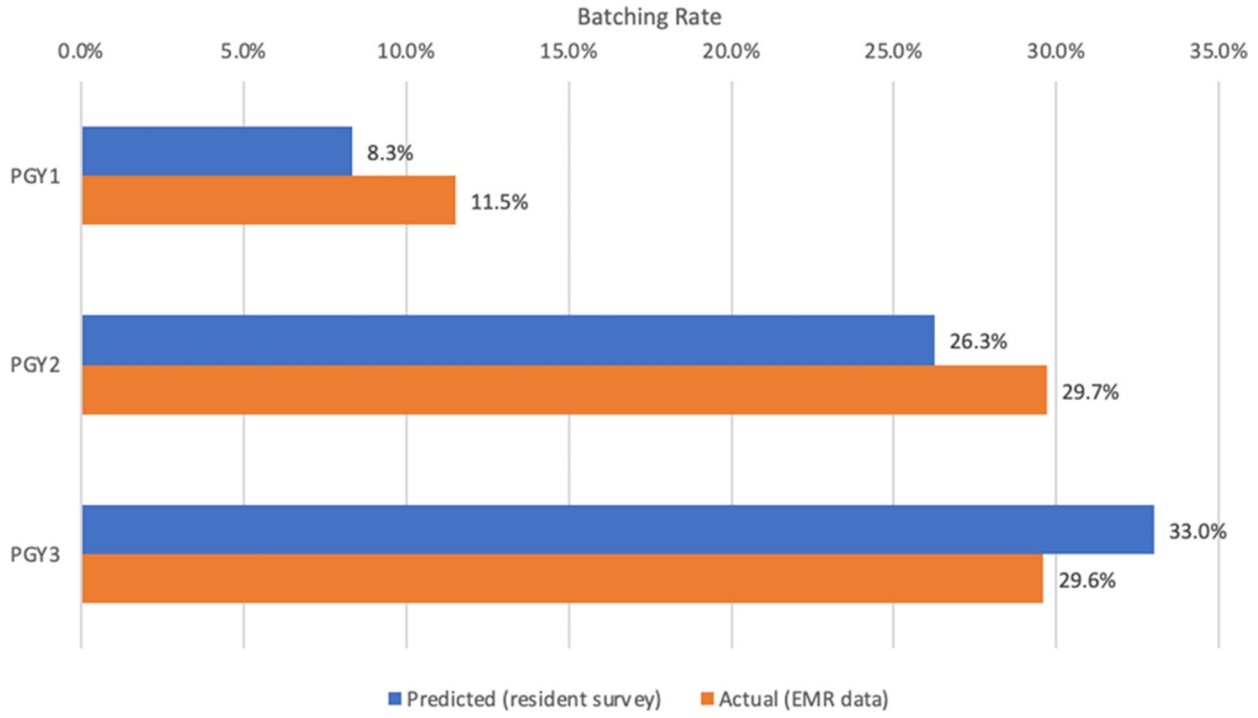

FIGURE 2 Resident-predicted versus actual batched assignment rate by PGY level.
Abbreviations: EMR, electronic medical record; PGY, postgraduate year.

actual rates and PGY3 residents slightly overpredicted actual rates. Figure 2 provides a summary.

The top ranked reasons for batching, both based on resident self-reporting and peer predictions were (1) economy of motion—seeing multiple patients while up from workstation, (2) beginning of shift—desire to see multiple patients when your census is zero, and (3) many patients to be seen—long physician next to see list. The lowest ranked reason was cherry picking—picking up a less desirable patient to get to an interesting chief complaint. Figure 3 presents average rank by reason.

Subanalysis demonstrated a statistically significant (P value < 0.01) increase in batching rates during the first hour of our major resident shifts (ie, 6 a.m., 2 p.m., 10 p.m.), consistent with the second-highest ranked perceived/reported driver of resident batching. Batching rate during the first hour of major resident shifts was 34.8%, compared to 21.4% for all other hours.

Residents demonstrated mixed perceptions on the effect of batching on LOS. Of those who responded to the survey, 50% predicted a shorter LOS because of batching, 14% predicted no difference, and 36% predicted a longer LOS. Of the last group, half predicted a less than 5 minute longer LOS and half predicted a 5–30 minutes longer LOS. Figure 4 details resident responses.

4 | LIMITATIONS

Our study has several significant limitations. The definition of resident–patient assignment batching is foundational to this study. With no generally accepted definition, we attempted to set a clinically appropriate cutoff based on an independent time and motion study and clinical judgment. We further attempted to minimize this limitation by analyzing a frequency histogram and conducting a sensitivity analysis of our results to different definitions. That said, this definition represents a simplification and cannot completely reflect the nuance of batching behavior.

Second, the study did not capture the number of patients in queue at the time of resident signup. At times when a single patient is in the queue, the opportunity to batch is not available, and as a result it is plausible that throughput would be faster (and LOS shorter) because there would not be competing tasks.

In addition, owing to data limitations, we included discharged patients only. This limits the ability to extrapolate results to all ED patients. The results may also be confounded by ongoing quality improvement efforts focused on patient LOS within the ED. The small sample size and timing of our resident survey represent additional limitations. The survey was conducted after a grand rounds lecture on operational efficiency that touched on the benefits of single patient assignment, potentially confounding resident perceptions as characterized in the survey. Of note, the data set used for all other analysis, including determination of batching rates and in-room LOS, was extracted before this lecture. In addition, survey responses regarding cherry picking may exhibit a social desirability bias. As a retrospective study, the results are subject to the bias and lack of control inherent to this study type.

Finally, this study was conducted at a single, large, academic, tertiary care center staffed predominantly by emergency residents, limiting its applicability to similar institutions.

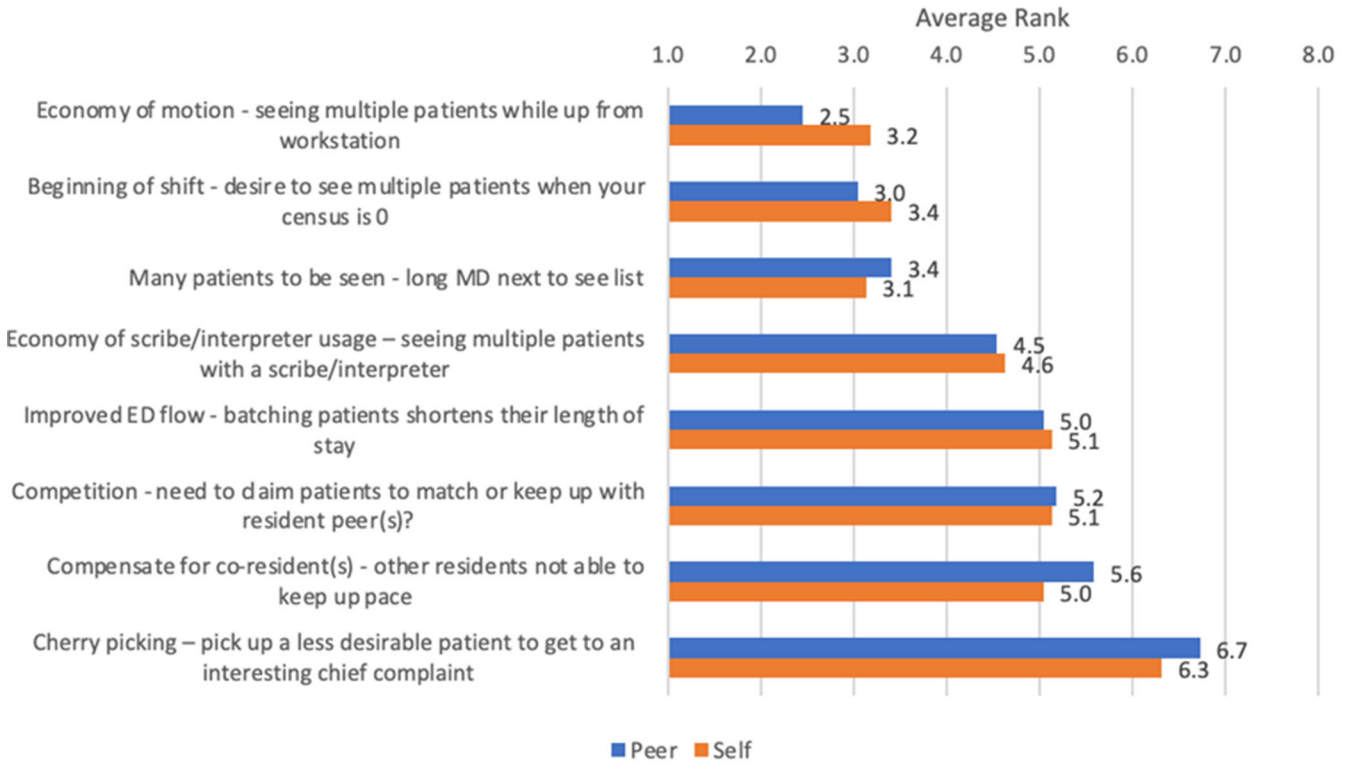

FIGURE 3 Resident reasons for batched assignment, personal and presumed peer reasons

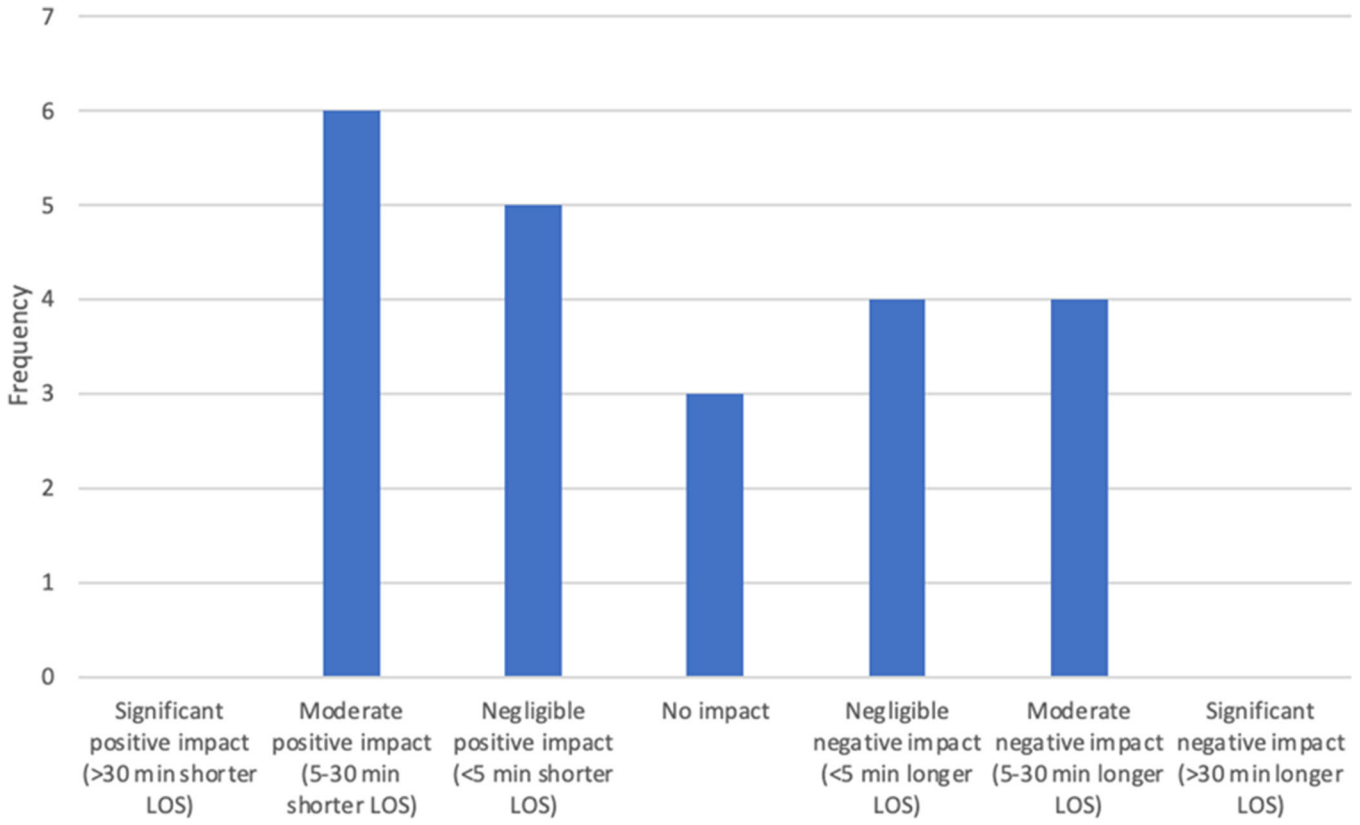

FIGURE 4 Resident-predicted effect of batched assignment on length of stay (LOS)

5 | DISCUSSION

In this study of patient self-assignment behaviors in an academic emergency department, we found that resident physicians batched patients with remarkable frequency, accounting for nearly one quarter of their patients. Rates of batching increased with resident seniority, such that senior residents batched nearly 30% of their patients. Our study demonstrates an operational cost to assignment batching, consistent with the theoretical inefficiency suggested by queueing theory. In our study, batched patients on average spent 15.9 minutes longer in room, a 5.6% increase over single assignment patients. As an observational study, natural confounding factors exist. Specifically, higher rates of batching occur with senior residents and in residents' first hour of shift. Prior literature has demonstrated these factors to also be correlated with higher resident productivity.[21] These factors likely underestimate the batching effect on LOS. Analysis of patient characteristics showed that batched patients had a small but statistically significant difference in acuity compared with single assignment patients. Batched patients averaged ESI 2.59 and single patients averaged ESI 2.51. In the context of increasing average in-room LOS being correlated with increasing acuity (ESI 3 at 278 minutes and ESI 2 at 311 minutes), we do not believe this 0.08 statistically significant difference in ESI to be clinically significant, and in fact the lower average ESI among single patients makes their shorter LOS more noteworthy. In general, our LOS results suggest that reducing patient assignment batching may provide a low- or no-cost means of improving patient LOS.

Strikingly, the residents surveyed in our study had views of batching that run opposite to its LOS cost. There are several potential explanations for this behavior. First, residents' productivity improves with experience.[22] Some residents may associate higher volumes of patient signups early in their shifts with greater productivity, even if this unknowingly leads to lower overall productivity and longer LOS.[23,24] Within this system, in which signups are purely resident driven, batching may also grant senior residents a greater sense of independence. For example, if residents wait until they have seen all their assigned patients before staffing them with an attending physician, then they may have a longer window in which to manage their first patients independently before they present to an attending, who may recommend a different plan of care.

Some small but consequential exceptions may exist to the potential negative effects of batching. For instance, many residents noted a preference for seeing multiple patients before they had to return to their workstation. Accordingly, residents might be able to make some gains in efficiency by batching a second patient who is low on the list of patients to be seen when they are located near a patient they are seeing (for instance, a patient with an ankle sprain next door to a patient with chest pain). Similarly, in some contexts where residents know they will see a patient later in the queue, such as a senior resident on an overnight with an off-service resident who cannot perform a needed procedure, then there is no significant increase to patient LOS with batched assignment.

In an environment of worsening ED crowding, administrators should view our study findings as a potential opportunity and as a catalyst for further investigation of physician assignment. Modifying human behavior and established clinical or organizational practices can be difficult.[25,26] However, addressing residents' underlying reasons for assignment batching is necessary and possible. Our survey results indicate the top 2 reasons for batched assignment are (1) the desire to see multiple patients while up from your workstation and (2) the desire to see multiple patients at the beginning of your shift. EHR-based patient assignment and near-ubiquitous exam room workstations could enable a small change to resident workflow that satisfies these underlying reasons and obviates the need to batch. Such a change could involve residents using the exam room workstation to identify and sign up for their next patient immediately before leaving the room, rather than signing up for multiple patients before seeing the first. Residents cite a long "next to see" list as the third most common reason for batching. Overcoming this reason in many cases will require cultural change, emphasizing a focus on efficient patient care over a "clean" board.

Addressing resident reasons for batching is possible, but as the saying goes, "the first step is admitting you have a problem." Our survey data suggest residents do not naturally appreciate the operational cost associated with batching. Specifically, half of residents characterized batching as having either a neutral or improved effect on patient LOS.

In summary, this study demonstrated that emergency residents frequently batched patients during assignment. Batching was associated with a prolonged patient LOS, but resident physicians did not universally anticipate this effect. Our findings suggest a potential opportunity for a patient LOS-improving intervention by changing assignment behavior. However, implementation may require further investigation, specifically to study potential confounders, more deeply understand physician drivers of assignment batching and characterize operational benefits of batching.

CONFLICTS OF INTEREST

The authors report no meetings, grants, or conflicts of interest.

AUTHOR CONTRIBUTIONS

Bryan Imhoff conceived of the study. Bryan Imhoff, Kenneth D. Marshall, Joshua W. Joseph, and Nima Sarani developed the definition of batching and inclusion/exclusion criteria. Bryan Imhoff performed the initial data gathering and preliminary analysis. Niaman Nazir provided comprehensive statistical analysis. Bryan Imhoff drafted the manuscript, and all authors contributed substantially to its revision. Bryan Imhoff takes responsibility for the manuscript as a whole.

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How to cite this article: Imhoff B, Marshall KD, Joseph JW, Sarani N, Kelman J, Nazir N. The effect of batched patient–physician assignment on patient length of stay in the emergency department. *JACEP Open*. 2022;3:e12784. https://doi.org/10.1002/emp2.12784