Predictors of Emergency Physician Productivity in a National Emergency Medicine Group

Jonathan J. Oskvarek, MD, MBA*; Mark S. Zocchi, PhD, MPH; Bernard S. Black, JD, MA; Laura G. Burke, MD, MPH; Marika Kachman, MD; Andrew Leubitz, DO, MBA; Ali Moghtaderi, PhD; Dhimitri A. Nikolla, DO, MS; Nishad Rahman, MD; Jesse M. Pines, MD, MBA

*Corresponding author. E-mail: oskvarekj@usacs.com.

Study objectives: We sought to identify physician and environmental factors (eg, crowding) associated with emergency physician productivity, measured as patients per hour. We also assessed whether physician productivity is associated with higher emergency department (ED) return rates.

Methods: We used data from 184 EDs in 24 states staffed by a national ED group from January 2021 to December 2022. Clinical outcomes were 72-hour returns and returns with admission. We performed multivariable linear regression models that included physician, shift, and facility characteristics.

Results: We examined 234,146 shifts among 2,099 physicians. The mean number of patients per hour was 1.94 (SD = 0.57). Physician factors associated with a higher number of patients per hour included younger age and longer tenure at a site, with the number of patients per hour increasing even after 60+ months at a site. Longer tenure at a site was associated with a higher number of patients per hour (0.06 [95% confidence interval {CI} 0.02 to 0.09] at 6 months and 0.11 [95% CI 0.07 to 0.15] at 12 months). The number of patients per hour was weakly associated with shifts worked in the prior 3 to 30 days (0.003 number of patients per hour [95% CI 0.002 to 0.004] for each additional shift). Overnight shifts, non-Monday shifts, more physicians working on shift, and longer shift lengths were associated with a lower number of patients per hour. The number of patients with ED length of stay more than 6 hours (boarding patients) was negatively associated with the number of patients per hour. The higher number of patients per hour, both within site and within physician, was associated with slightly decreased 72-hour returns but no meaningful difference in returns with admission.

Conclusion: Both physician- and shift-level factors are associated with emergency physician number of patients per hour. Higher number of patients per hour is not associated with increased 72-hour returns with admission. [Ann Emerg Med. 2025;86:347-358.]

Please see page 348 for the Editor's Capsule Summary of this article.

Keywords: Productivity, Crowding, Boarding, 72-hour returns, Patient safety.

Readers: click on the link to go directly to a survey in which you can provide feedback to Annals on this particular article.
A **podcast** for this article is available at www.annemergmed.com.

0196-0644/$-see front matter

https://doi.org/10.1016/j.annemergmed.2025.02.002

SEE EDITORIAL, P. 371.

INTRODUCTION

Background

Emergency physician productivity is an important metric, as emergency department (ED) care requires rapid and accurate diagnosis and treatment with limited resources.[1-3] Physician productivity is typically measured as the number of patients per hour or relative value units (RVU) per hour generated over a fixed period (eg, a shift, a month, or a year). More productive physicians typically generate more revenue and may contribute to more efficient ED operations.[4] However, there is a risk that more productive physicians might provide lower quality care if they spend less time with patients. Despite worsening ED crowding, nursing shortages, and higher acuity patients since the coronavirus 2019 (COVID-19) pandemic, expectations for emergency physician productivity have increased in some EDs.[5-7]

Importance

Several studies have examined factors influencing emergency physician productivity. Higher productivity (number of patients per hour and RVUs) is associated with the presence of residents and scribes, who can replace some work otherwise performed by attending physicians.[8-11] Advanced practice providers have very small effects on productivity.[12] Physicians tend to be more productive early

Editor's Capsule Summary

What is already known on this topic

Physician productivity is a common emergency department (ED) operations metric.

What question this study addressed

What are physician productivity outcome measures and what modifies them?

What this study adds to our knowledge

In review of over 2,000 physicians and 230,000 shifts in 184 EDs, mean patients-per-hour was 1.94. Several physician and environmental factors, including age, site tenure, shift timing, and ED boarding, were associated with different productivity. Increased productivity was not associated with increased 72-hour returns with admission.

How this is relevant to clinical practice

These data can inform emergency physician recruitment and deployment.

in a shift.[13] In a 2-site correlational study, more productive physicians had lower hospital admission rates and computed tomography (CT) utilization rates without increasing 72-hour return ED visits.[14]

However, there is little evidence on why physicians vary in their productivity or how shift conditions affect it, holding physician factors constant. Identifying physician and shift characteristics that affect productivity can inform efforts to ensure appropriate ED staffing and mitigate patient safety concerns. There is also limited evidence on the relationship between productivity and the rate of 72-hour returns.

Goals of This Investigation

We assessed both physician- and ED-level factors associated with emergency physician number of patients per hour for a large sample of EDs staffed by a national ED staffing group. We also examined the associations between the number of patients per hour and 72-hour return visits and admitted 72-hour returns.

MATERIALS AND METHODS

Study Design and Setting

This was a retrospective observational study of administrative, billing, clinical, and scheduling data from 184 EDs in 25 states staffed by a national ED staffing group from January 2021 to December 2022. We used shift- and visit-level data abstracted from billing records, electronic health records, scheduling software (Shift Admin, Columbia, SC), and physician demographic records. The study was approved by the Institutional Review Board at Allegheny Health Network (#2021-016).

Measurements

The national group (US Acute Care Solutions) maintains a physician staffing database and employs its own billing and coding specialists who extract ED visit data, using a data dictionary, including patient demographics and diagnoses, from electronic health records at each site. The data are then placed into a data warehouse. Data are then deidentified and maintained as research data sets. These data sets have been described previously.[5,15,16] Staffing data reflect the assigned shift times that physicians can manually adjust if they did not work the scheduled shift time (eg, left a shift early due to low volumes or stayed late). This may include time signing out to the oncoming physician.

Study Sample

The initial sample included 361,007 shifts from 2,556 physicians at 213 sites. We excluded shifts less than 6 hours or longer than 14 hours as these are atypical shift lengths. We removed shifts with less than one patient per hour because these are shifts where physicians are not near their workload capacity. We also excluded shifts at teaching hospitals because educational priorities may affect the number of patients per hour. We excluded shifts covered entirely by a single physician to limit bias from lower volume, single coverage times of day, and from lower volume single coverage sites for which patient arrivals are the main driver of the number of patients per hour. Physicians with fewer than 10 shifts at a site during the study period were excluded out of concern that their number of patients per hour may differ from physicians with higher shift volumes. For physicians who worked at multiple sites during the study period, we only included shifts at the site where the physicians worked the majority of their shifts. The final sample included 234,146 shifts, 2,099 physicians, and 184 sites (Table E1, available at http://www.annemergmed.com). Table E2 (available at http://www.annemergmed.com) describes ED characteristics. Payment model varied by site, with some sites in the group having RVU-based pay, but we lack this data.

Outcomes

The productivity outcome was the number of patients per hour, measured at the shift level. At all sites, visits were attributed to a shift if they arrived during or up to 12 hours prior to the start of the physician shift, and the physician's provider identification number matched the primary rendering identification number on the patient's visit

record. The provider identification number is unique to each physician. Only 1% of the visits in the data were shared between a physician and an advanced practice provider (in our group, advanced practice providers can independently evaluate and disposition patients, although, at some sites, a physician is needed if a patient is to be admitted). The attribution of the visit to a physician or an advanced practice provider is determined by group coders who evaluate physician contributions based on the content of their notes. If 2 or more physicians were assigned to the patient, coders assign the visit to one physician and distribute RVUs based on the contribution to patient care described in their notes. We also conducted a sensitivity analysis using RVUs per hour as the productivity measure because the number of patients per hour may not fully account for visit complexity and procedures. For shared visits between a physician and an advanced practice provider, we split the visit RVUs evenly between the physician and the advanced practice provider. Clinical outcomes were 72-hour returns to the same ED and 72-hour returns to the same ED with admission among patients who were treated and released from the ED. An admission was defined as hospital admission, observation stay, or transfer to another facility (generally for admission at the second facility).[17-19]

Predictor Variables

We included a broad set of predictor variables in the analysis to account for physician and shift characteristics that may affect the number of patients per hour and 72-hour returns (Table E3, Appendix E1, available at http://www.annemergmed.com). Predictors of the number of patients per hour included physician characteristics (eg, physician age, sex, and months since first shift at the facility), shift characteristics (eg, shifts worked within 48 hours and within 3 to 30 days, length of shift, overnight shift, shift time of day, and day of the week), and ED operational characteristics (eg, total patients with ED length of stay less to or more than 6 hours at the start of the shift and number of other physicians and advanced practice providers working at the start of the shift). We used a length of stay longer than 6 hours as a proxy for boarding patients. Patient covariates included visit payer source (ie, Medicare, Medicaid, commercial, and self-pay), Evaluation and Management Codes, Emergency Severity Index (ESI), and RVUs per patient, as these factors can be associated with both the number of patients per hour and 72-hour returns although they were not the focus of this study. ESI data was missing for 14% of the encounters. Missing ESI values were imputed using multivariable linear regression (Appendix E2, Table E11, available at http://www.annemergmed.com).

Analysis

Descriptive statistics of variables related to physicians, shifts, and visits were calculated. We constructed multivariable linear models with productivity as measured by shift level the number of patients per hour as the primary outcome. Separate models were estimated using either physician or facility-fixed effects. The physician-fixed effects model examined the association between shift characteristics (eg, shift timing, types and acuity of patients, patients with ED length of stay more than 6 hours) and shift-level number of patients per hour, adjusted for the average of the number of patients per hour of the physicians working at the facility across all shifts. The facility-fixed effects model examined the association between physician characteristics (eg, age, sex, and time since first shift at that site) and the number of patients per hour, effectively comparing physicians working in the same ED and, thus, exposed to a similar case mix. This model also incorporated shift characteristics (eg, shift timing, types and acuity of patients, number of patients, and patients with ED length of stay of more than 6 hours at start of shift) as covariates for adjustment. We repeated our models using RVUs per hour rather than the number of patients per hour as the primary productivity indicators.

Next, we examined the association between physician's number of patients per hour and 72-hour returns using both physician-fixed effects and facility-fixed effects at the visit-level. We studied separately all return visits and return visits with admission. The physician-fixed effects model examines whether a given physician has more 72-returns for patients seen on a more productive (busier) shift compared with a less productive shift. The facility-fixed effects model examines whether physicians who have more patients per hour have more 72-hour returns than physicians with fewer patients per hour, controlling for facility and, thus, for characteristics of both the facility and the patients who visit the facility. For both models and both outcomes, we used a linear probability model with 72-hour returns as the outcome and the number of patients per hour as a linear predictor, incorporating patient characteristics (age, sex, payer source, arrival time, arrival day, ESI, total RVUs, and body system of primary diagnosis) as well as crowding at the time of the ED visit as covariates. Analyses were conducted using Stata v.17 (StataCorp LLC).[20]

RESULTS

Characteristics of Physicians and Shifts

The largest proportions of emergency physicians in our sample were aged under age 35 (26.6%) and 35 to 39 years (21.6%) (Table 1). About two-thirds were men (66.1%). Most shifts (59.6%) were staffed by physicians

Table 1. Physician and shift characteristics.

Characteristics	Mean/%	(SD)	Median	(IQR)
N				
Total clinicians	2,099			
Total shifts	234,146			
Outcomes, mean/median (SD/IQR)				
Visits per clinician h	1.94	(0.57)	1.88	(1.50-2.25)
RVUs per clinician h	9.23	(2.88)	8.93	(7.18-10.93)
Clinician/shift contextual factors, mean/median (SD/IQR)				
Shifts worked in last 3-30 d	11.8	(3.8)	12.0	(10.0-14.0)
Length of shift, h	9.1	(1.5)	9.0	(8.0-10.0)
Clinician/shift contextual factors, % of shifts				
Time since first shift at site (mo)				
<2 mo	6.8			
2-3.99	6.7			
4-5.99	5.9			
6-7.99	3.0			
8-9.99	2.9			
10-11.99	2.7			
12-17.99	6.7			
18-23.99	5.8			
24-35.99	12.1			
36-47.99	14.8			
48-59.99	12.7			
60 + months	20.0			
Shifts worked in last 48 h				
No shifts	34.1			
1 shift	50.1			
2 shifts	15.8			
Overnight shift				
No	60.9			
Yes	39.1			
Shift time of day				
12 AM to 6:59 AM	14.1			
7 AM to 2:59 PM	40.9			
3 PM to 11:59 PM	44.9			
Shift day of week				
Monday	14.9			
Tuesday	14.8			
Wednesday	14.5			
Thursday	14.2			
Friday	14.4			
Saturday	13.6			
Sunday	13.6			
ED occupancy factors, mean/median (SD/IQR)				
Total patients with ED LOS >6 h per 1,000 annual volume at start of shift	24.2	(38.0)	11.0	(0.0-29.8)
Total patients with ED LOS <6 h per 1,000 annual volume at start of shift	120.7	(92.9)	100.0	(49.5-168.6)
Avg LOS per patient at start of shift (h)	7.0	(6.8)	4.9	(3.0-8.5)

Table 1. Continued.

Characteristics	Mean/%	(SD)	Median	(IQR)
Total other physicians working at start of shift	0.8	(0.9)	1.0	(0.0-1.0)
Total APPs working at start of shift	1.0	(1.0)	1.0	(0.0-2.0)
Characteristics of visits treated during shift, mean/median (SD/IQR)				
% visits admitted/txfr	29.0	(17.6)	27.3	(15.4-40.7)
ESI level of visits seen during shift	2.9	(0.3)	2.9	(2.7-3.1)
% Visits female patient	54.2	(13.1)	54.2	(45.5-63.0)
% Visits patient <10 y	5.8	(11.6)	0.0	(0.0-7.7)
% Visits patient >55 y	46.2	(17.9)	46.7	(34.3-58.3)
% Visits commercial insurance	24.9	(13.5)	23.5	(15.4-33.3)
% Visits uninsured or Medicaid	37.9	(17.2)	36.8	(25.0-50.0)
Primary diagnosis body system (top 5 shown), % of visits, mean/median (SD/IQR)				
Injury, poisoning, and certain other consequences of external causes	16.3	(10.7)	15.4	(8.3-23.1)
Symptoms, signs, and abnormal clinical and laboratory findings	16.1	(10.6)	15.0	(8.3-22.2)
Diseases of the circulatory system	13.7	(9.8)	12.5	(6.7-20.0)
Diseases of the respiratory system	7.5	(7.7)	6.3	(0.0-11.1)
Certain infectious and parasitic diseases	7.3	(8.2)	5.9	(0.0-11.1)
Clinician characteristics, % of clinicians				
Clinician age, y				
<35	26.6			
35-39	21.6			
40-44	15.8			
45-49	12.0			
50-54	10.6			
55-59	6.1			
60-64	4.2			
>65	3.1			
Clinician sex				
Female	33.9			
Male	66.1			

RVU, relative value units; *LOS*, length of stay; *APP*, advanced practice provider; *ESI*, emergency severity index.

who had been working at their sites for 24 months or longer. Half of physicians (50.1%) worked one shift within 48 hours before the index shift. Physicians worked a mean of 11.8 shifts (SD = 3.8) in the 3 to 30 days prior to a given shift, with mean shift length of 9.1 hours (SD = 1.5). Shifts were spread relatively evenly throughout the week, and 39.1% were night shifts (ie, spanned midnight). The sites had a mean of 4.2 patients with ED length of stay of more than 6 hours (SD = 6.3) and 21.2 patients with ED length of stay of more than 6 hours (SD = 15.4) present at shift start. There was a mean of 0.8 other physicians (SD = 0.9) and one advanced practice provider (SD = 1.0) working at shift start. The mean number of patients per hour was 1.94 (SD = 0.57).

Physician Factors Associated with the Number of Patients per Hour

In our facility-fixed effects model, we found several physician factors associated with productivity (Figure 1, Table E4, available at http://www.annemergmed.com). Younger physician age was associated with a higher number of patients per hour. Compared with the reference group of under 35 years old, the number of patients per hour for physicians aged 35 to 39, 40 to 44, 45 to 49, and 50 to 54 were similar, but physicians aged 55 to 59 years had a lower number of patients per hour, with an adjusted mean difference of −0.11 the number of patients per hour (95% CI −0.17 to −0.06); −0.07 (95% CI −0.14 to −0.002) for 60 to 64 years, and similar (−0.08 [95% CI −0.16 to −0.006]) for ages 65+ (Figure 1, Table E4). Male

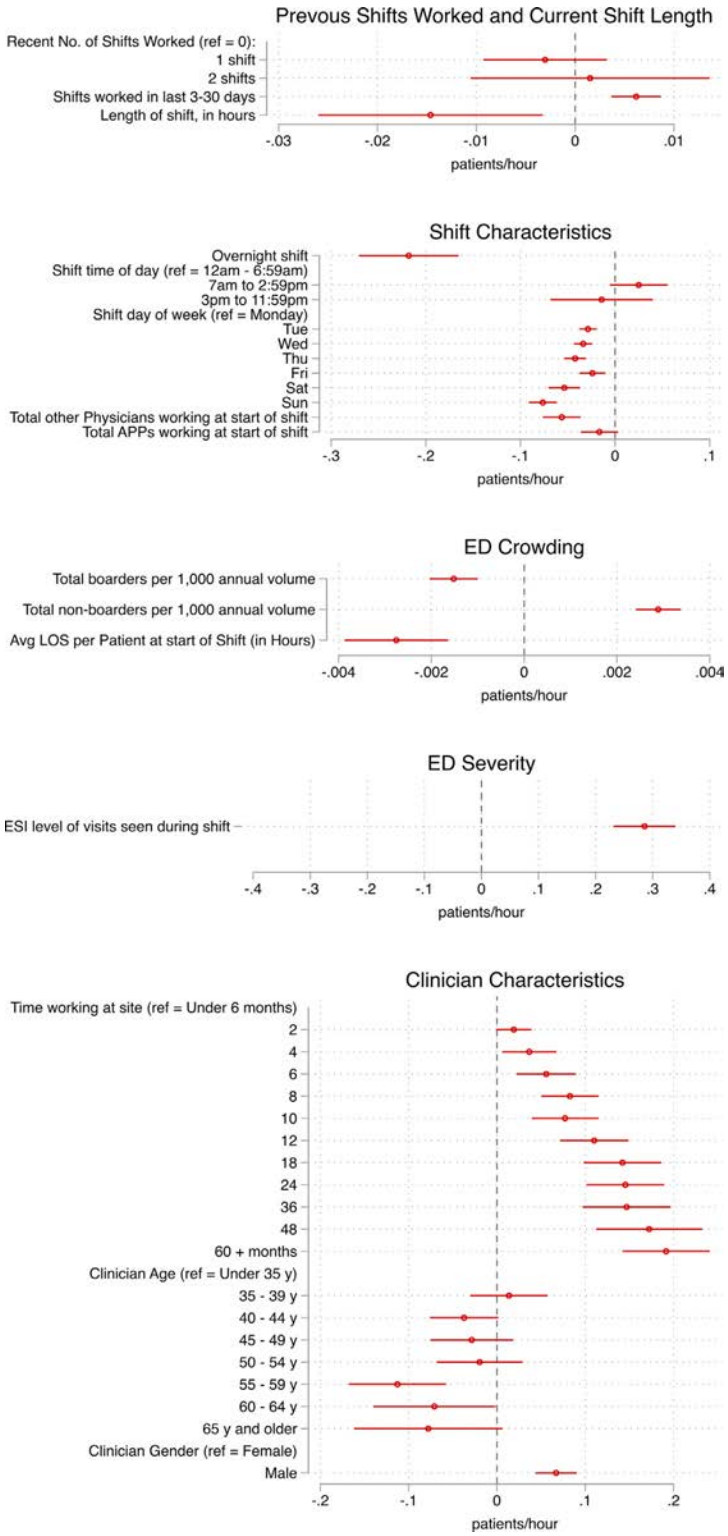

Figure 1. Influence of predictor variables on patients per hour from facility-level fixed model. Panels show coefficients and 95% confidence intervals for selected predictor variables from regressions of patients per hour on a full set of predictor variables, with

physicians had a higher number of patients per hour (adjusted mean difference of 0.07 for number of patients per hour [95% CI 0.04 to 0.09]) than female physicians. Longer tenure at a site was associated with progressively higher adjusted mean of the number of patients per hour (0.06 [95% CI 0.02 to 0.09] at 6 months, 0.11 [95% CI 0.07 to 0.15] at 12 months, 0.15 [95% CI 0.10 to 0.19] at 24 months), 0.17 [95% CI 0.11 to 0.23] at 48 months, and 0.19 [95% CI 0.14 to 0.24] at 60+ months. A separate model with an interaction between physician age and months at site had a nonsignificant interaction for these variables (Table E6, available at http://www.annemergmed.com).

Shift-Level Factors Associated with Physician Number of Patients per Hour

In the physician-fixed effects model, the number of shifts worked in the last 3 to 30 days had a positive association with the number of patients per hour (0.003 of the number of patients per hour [95% CI 0.002 to 0.004] for each additional shift worked) (Figure 1, Table E4). Compared with none, having worked 1 shift in the last 48 hours was associated with a small decrease in the number of patients per hour (−0.005 [95% CI −0.010 to −0.001]), but there was no significant association with facility-fixed effects. Overnight shifts were associated with a lower number of patients per hour (−0.18 of the number of patients per hour, 95% CI −0.23 to −0.14, Figure 2). Compared with Monday, shifts on other days of the week (especially weekends) were associated with a lower number of patients per hour (Figure 1, Table E4). Each additional hour in shift length (beyond the minimum length of 6 hours) was associated with a lower number of patients per hour (0.01 [95% CI −0.02 to −0.003]. Total other physicians working at the start of the shift were associated with a lower number of patients per hour (−0.04 [95% CI −0.06 to −0.03]), but advanced practice providers working at the start of a shift were not. Total patients with ED length of stay less than 6 hours (measured per 1,000 annual ED visits) had a small but significant association with decreased number of patients per hour (−0.002 the number of patients per hour per patient [95% CI −0.002, −0.001]), whereas these patients were associated with higher number of patients per hour in the facility-fixed effect model (0.009 of the number of patients per hour [95% CI 0.002 to 0.003]) (Figure 3). Lower patient severity (higher average ESI) was associated with a lower number of patients per hour (Figure 1, Table E4).

Association Between Physician Number of Patients per Hour and 72-Hour Return Visits

Holding all other covariates in the physician-fixed effects model constant, a one-unit change in the number of patients per hour was associated with a slightly lower 72-hour overall return rate of −0.001 (95% CI −0.002 to −0.0004), which represents a change of 0.1%. There was no association between the number of patients per hour and return visits with admission (−0.0003 [95% CI −0.0006 to 0.00005]) (Figure 4, Table 2, Tables E7 and E8, available at http://www.annemergmed.com). In the facility-fixed effects model, we again found that the higher physician number of patients per hour was associated with fewer 72-hour returns overall, with no significant difference for return visits with admission. Thus, patients seen by more productive physicians did not have a greater risk of 72-hour returns.

We also studied quintiles of physician productivity as categorical predictors. In the facility-fixed effects model, the percentage of patients returning within 72 hours was similar by quintile of physicians (4.5% [95% CI 4.4% to 4.6%] for the 1st quintile [lowest the number of patients per hour] vs. 4.4% [95% CI 4.3% to 4.4%] for the fifth quintile) (Table 3). Return visits with admission occurred in 1.1% of visits to physicians in the 1st quintile of productivity (95% CI 1.1% to 1.2%) and 1.1% of patients in the fifth quintile (5th quintile 95% CI 1.1% to 1.1%).

Sensitivity Analyses

We examined RVUs as an alternative measure of productivity. Physician- and shift-level factors associated with RVUs were similar to the analysis using the number of patients per hour as the productivity outcome (Table E5, available at http://www.annemergmed.com). Additionally, given that we imputed ESI for 14% of the visits, we constructed models for 72-hour returns (and 72-hour returns leading to admission) with and without ESI, and the results were not qualitatively different (Table E9 and E10, available at http://www.annemergmed.com).

LIMITATIONS

This study relies on data from a single national ED group. However, the diverse nature of the EDs studied, in size and geography, mitigates some concerns about generalizability. Second, our exclusion criteria may have affected results. For example, we examined only shifts at sites with more than one physician present for at least part

facility-fixed effects (Table E3). Mean number of patients per hour was 1.94, and total sample was 234,146 shifts, 2,099 physicians, and 184 sites. Standard errors are clustered on facility. Minimum included shift length was 6 hours. *RVU*, relative value units; *LOS*, length of stay; *APP*, advanced practice provider; *ESI*, emergency severity index.

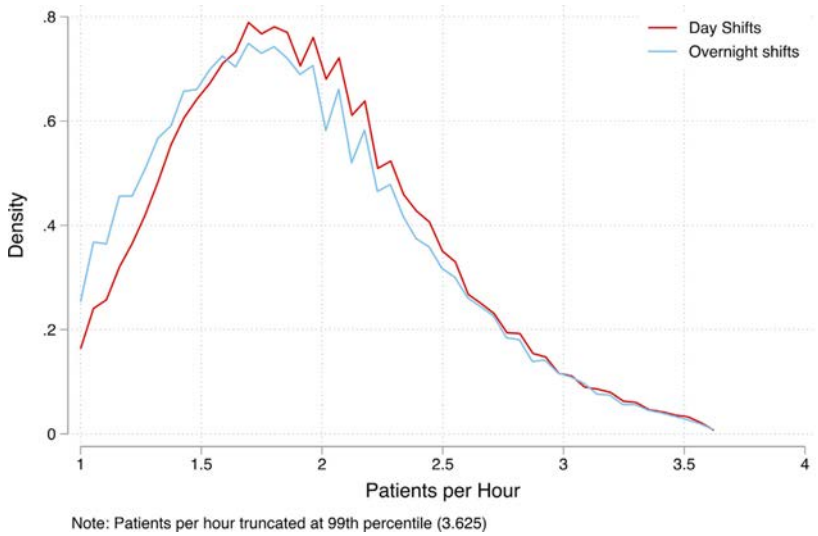

Figure 2. Kernel density plot of productivity (patients per hour) for day and night shifts. Plot visualizes the distribution of patients per hour for day shifts and overnight shifts from regressions of patients per hour on full set of predictor variables with facility-fixed effects. In the table, the top row is patients per hour, and the bottom row is the total number of patients in the data set.

of the shift and shifts with the number of patients per hour of one or more. This focused the analysis on shifts in which productivity of an individual physician could vary (ie, they are not working under solo coverage and see all patients) and in which there are plentiful patients to be seen. We also excluded shifts at teaching hospitals. The data set does not

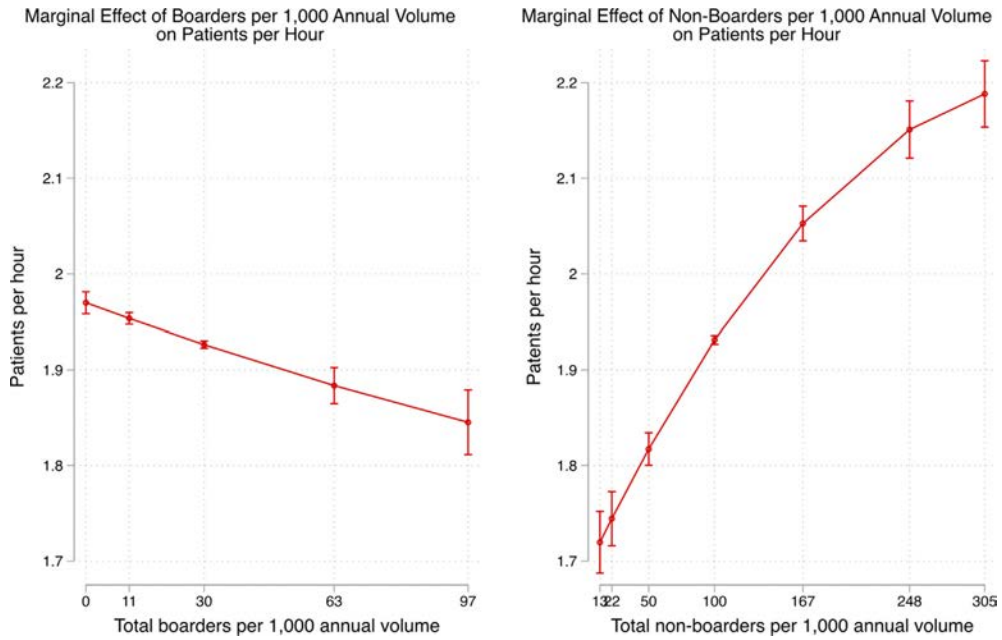

Figure 3. Effect of boarders and nonboarders on patients per hour. We use patients with ED LOS >6 hours as a proxy for boarders and ED LOS <6 hours as a proxy for nonboarders. Panels show point estimates and 95% confidence intervals for number of boarders and nonboarder patients present at start of shift (quadratic terms), with other predictors held at their means values from regressions of patients per hour on full set of predictor variables, with facility-fixed effects. The ranges of the x-axes correspond to the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of boarders/nonboarders present at the start of a shift. The number of boarders present *at the start of the shift* is scaled to the *annual ED volume,* which is a proxy for ED size. Standard errors are clustered on facility. In the table, the top row is annual visit volume in thousands, and the bottom row is the total number of boarders per year.

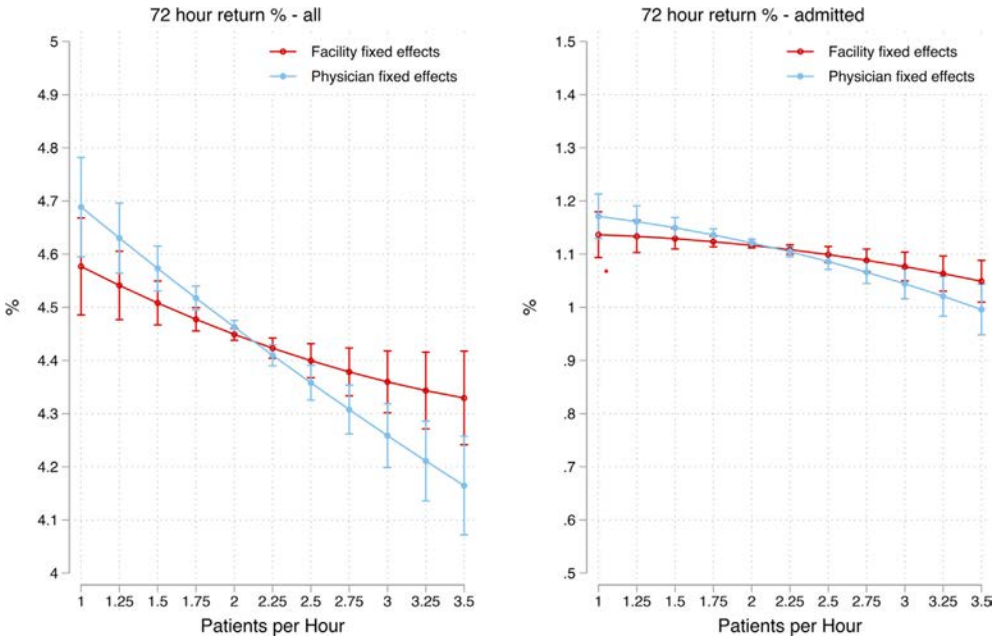

Figure 4. Marginal effect of patients per hour on 72-hour returns. Panels show point estimates and 95% confidence intervals for 72-hour returns and 72-hour returns, resulting in admission across physician productivity (measured in patients per hour) with other predictors held at their mean values from regressions of patients per hour on full set of predictor variables, with facility-fixed effects (FEs). X-axes span approximately the 10th to 90th percentiles of patients per hour. Standard errors are clustered on facility. In the table, the top row is patients per hour, and the bottom row is the total number of patients in the data set.

indicate when medical students or other learners are involved, which may affect results. Third, this study cannot assess causal relationships between physician and shift factors, as well as productivity or quality. This includes an inability to determine whether 2 physicians see different types of patients while on shift together or if some physicians try to select patients to increase RVUs and, thus, reimbursement. We also lack data on why certain physicians were assigned to certain shifts.

Table 2. Marginal effect of patients per hour on the probability of a 72-hour return.

Probability Model and Metric	Estimate	Lower Limit	Upper Limit
Facility-fixed Effects			
72-h Returns—all	−0.11%	−0.18%	−0.04%
72-h Returns—admitted	−0.03%	−0.06%	0.00%
Physician-Fixed Effects			
72-h Returns—all	−0.21%	−0.28%	−0.14%
72-h Returns—admitted	−0.07%	−0.10%	−0.03%

The table shows point estimates and 95% confidence intervals of the marginal effect of a 1-unit increase in physician shift productivity (ie, +1 patient per hour) on the probability of a 72-hour return, with other predictors held at their mean values. Estimates are derived from the visit-level linear probability models that include patient, shift, physician characteristics, and facility or physician-fixed effects using clustered standard errors. 72-hour returns are scaled from 0%-100%.

Fourth, there may be unmeasured variables that affect productivity. Fifth, although we studied 72-hour returns to the same ED, we did not have data that would have allowed us to examine other patient quality and experience metrics, such as guideline adherence and patient experience. In particular, 72 hours are commonly used as suggestive of a missed diagnosis or other potential quality issue, but are not a sensitive or specific measure of care quality at the first visit.[21] Additionally, 72-hour return visits to another ED outside of the national group were not identified in our data. Sixth, we imputed ESI for 14% of the visits. However, we obtained similar results when ESI was dropped as a covariate. Seventh, we do not account for where physicians work in the ED (ie, some physicians may tend to work in areas that see higher or lower acuity patients). Eighth, we did not assess reasons for differences in productivity (eg, spending more or less time with patients, performing more or less thorough workups, documenting less while on shift, taking more breaks, practicing to minimize medical-legal concerns, etc).

Ninth, physicians in our sample were younger (48.2% were 44 years or younger) versus the general population of emergency physicians (median age of 50 years according to an American College of Emergency Physicians's report), which could affect generalizability.[22] Tenth, we define boarding as a

Table 3. Quintiles of physician productivity and 72-hour returns.

	PPH Quintile Ranges			72-h Returns - Overall		72-h Returns - Admitted	
Quintile	Index Visits	Min	Max	Point Est.	(95% CI)	Point Est.	(95% CI)
1	379,421	1.00	1.44	4.505	(4.429-4.582)	1.119	(1.082-1.156)
2	519,867	1.45	1.75	4.504	(4.446-4.562)	1.128	(1.097-1.159)
3	545,998	1.75	2.00	4.447	(4.397-4.496)	1.114	(1.089-1.140)
4	562,159	2.00	2.38	4.445	(4.389-4.500)	1.119	(1.092-1.146)
5	749,298	2.38	7.43	4.377	(4.319-4.436)	1.082	(1.055-1.108)

The table shows point estimates and 95% confidence intervals across quintiles of physician shift productivity (patient per hour), with other predictors held at their mean values, from visit-level linear probability models for 72-hour returns and 72-hour returns resulting in admission with patient, shift, physician characteristics, and facility-fixed effects using clustered standard errors. Index visits refer patients discharged who did not have a previous visit within 72 hours. *PPH*, patient per hour.

patient with an ED length of stay longer than 6 hours. However, this definition may underestimate or overestimate the actual number of boarding patients. Eleventh, we included shifts in which there was only one physician on site for part of the shift, which could affect the number of patients per hour. Twelfth, the study period included the COVID-19 pandemic, during which changes in staffing and hospital operations may have affected the number of patients per hour in unmeasured ways. Thirteenth, the study period was prior to the changes in Medicare coding in 2023, which may affect applicability to current-day practice.

DISCUSSION

In our study, physician and shift factors were associated with productivity as measured by the number of patients per hour. Yet, a higher number of patients per hour was not associated with negative clinical outcomes as measured by higher rates of 72-hour returns and 72-hour returns with admission in either physician-fixed effects or facility-fixed effects models. We examined shifts with sufficient presenting volume (ie, the number of patients per hour of at least one) with more than one physician on shift. Physician factors associated with a higher number of patients per hour in the facility-fixed effects model (which examines physician factors relative to their particular EDs) included younger age, male sex, longer time at a site, and working more shifts in the last 30 days. Although there is no standard for a clinically significant change in the number of patients per hour, an increase of 0.1 of the number of patients per hour would be a roughly 5% difference, relative to the sample mean of 1.94, and would allow a physician to see one additional patient in a 10-hour shift. Because the number of patients per hour is a major factor in determining physician RVUs and, thus, payment for physicians paid on an RVU basis, physician and environmental characteristics (ie, boarding) can affect physician reimbursement. However, physician capability remains only one of several potential drivers of productivity, alongside hospital or departmental factors.

We found an association between increased age and a small decrease in the number of patients per hour, with group-specific coefficients around −5% for ages 55 to 59 compared with the youngest group (age <35). For a 55-year-old physician, this may amount to one fewer patient seen per 10-hour shift compared with a physician aged under 35 when considering only age as a factor. However, some older physicians may have a longer tenure at a site, so their overall productivity may not be lower than younger physicians with shorter tenure. The data may also not account for differences in the way younger versus older physicians select patients to see. Additionally, although physical endurance and cognitive processing speed tend to decrease in physicians with age, the effect of physician age on ED quality is mixed.[23-28] Some studies show older physicians are more likely to be named in malpractice cases, and their patients have higher mortality, whereas others show they order fewer tests and lower mortality.[29-31]

Male sex was associated with a slightly higher number of patients per hour (0.067 the number of patients per hour or about 3%). We do not view this statistically significant result as meaningfully different. We were unable to assess the reasons for this small difference; however, it may be that female physicians spend more time at the bedside with patients, which may lower their productivity compared with men.[32,33]

Longer tenure at a site was associated with higher productivity, with continued productivity increases seen up to 5 years at a site—the longest period our data allowed us to measure. Physicians with the longest tenure had a nearly 10% higher number of patients per hour (0.17 of the number of patients per hour) in the facility-fixed effect model. Our group previously published data showing productivity increases in the first 4 months at a site among new residency graduates, but longer-term productivity gains have not previously been reported.[16] Such an association may be explained by greater familiarity with site processes.

Notably, we did not find working 2 shifts close together in time to be associated with a meaningfully higher or lower number of patients per hour. We also found physicians working a higher volume of shifts had a 0.1% increase in the number of patients per hour (0.003 the number of patients per hour or about 0.05 patients per 10-hour shift) per previous shift worked in the last 3 to 30 days in the physician-fixed effect model. This falls below what we consider to be a meaningful difference except at the extremes of very high and very low volume physicians. Shift length had a small, but not meaningful, association with about 1% decreased number of patients per hour (−0.01 the number of patients per hour or 0.1 patients per 10-hour shift) per additional hour worked. This could be due to physicians slowing their pace of work near the end of a long shift.

Operational factors such as boarding, nurse staffing, laboratory throughput times, radiology coverage, environmental services, and other factors not within an emergency physician's control but can strongly influence productivity. Working during times with patients with ED length of stay longer than 6 hours (our proxy for boarding) decreased productivity in the physician-fixed effects model. To illustrate, a 50,000 annual visit ED with one extra boarder per shift is associated with −0.1 the number of patients per hour or −5% the number of patients per hour (Figure 3). In a 10-hour shift, one less patient would be seen, on average. Crowded EDs have previously been associated with delays in patient assessment and treatment and worse quality and outcomes.[34-40] The negative association with productivity is not surprising, given that crowded EDs are known to run less efficiently as resources become constrained. Mondays—often busier days—showed a 1% to 4% higher number of patients per hour, whereas overnight shifts —typically quieter—showed about 10% lower number of patients per hour. These associations suggest caution when comparing the number of patients per hour across physicians. For example, a night shift physician may be less productive due to lower night volumes and possibly differences in patient health and severity not fully captured by our covariates.

Higher number of patients per hour, whether across physicians within sites and across shifts for the same physician, was not associated with higher 72-hour returns or 72-hour returns leading to admission. We view the 0.1% decrease in overall 72-hour returns in the physician-fixed effects model to be not meaningful while still statistically significant. This suggests that there was no tradeoff observed between speed and this dimension of quality (ie, there is no evidence that working faster, within the range observed in our data, might increase 72-hour returns due to increased misdiagnosis). Such resiliency reflects, in part, emergency physician training, where managing the ED during busy times is a learned skill. However, further work is needed using more precise measures of diagnostic error, adverse outcomes, and other quality metrics. There is only one other study of the number of patients per hour and 72-hour readmissions, which also found no correlation.[14]

In conclusion, we found several important physician and shift factors that were associated with productivity with varying magnitudes. The most notable is the continued increase in the number of patients per hour with tenure at a site. Understanding these factors is vital to address the challenges faced by emergency physicians and optimize ED performance.

Supervising editor: Hemal K. Kanzaria, MD. Specific detailed information about possible conflicts of interest for individual editors is available at https://www.annemergmed.com/editors.

Author affiliations: From the US Acute Care Solutions (Oskvarek, Kachman, Leubitz, Nikolla, Rahman, Pines), Canton, OH; the Department of Emergency Medicine (Oskvarek), Summa Health System, Akron, OH; The Heller School for Social Policy and Management (Zocchi), Brandeis University, Waltham, MA; Beth Israel Deaconess Medical Center (Burke), Boston, MA; Adventist Shady Grove Medical Center (Leubitz), Rockville, MD; Department of Health Policy and Management (Moghtaderi), the Milken Institute School of Public Health, George Washington University, Washington, DC; Department of Emergency Medicine (Nikolla), Allegheny Health Network, Erie, PA; Department of Emergency Medicine (Rahman), Sinai Hospital, Baltimore, MD; Department of Emergency Medicine (Pines); George Washington University, Washington, DC; Pritzker School of Law and Kellogg School of Management, Northwestern University, Chicago, IL (Black).

Author contributions: All authors conceived the study and designed the analyses. BSB provided advice on study design. MSZ took the lead role in analyzing the data. JO drafted the manuscript, and all authors contributed substantially to its revision. JO takes responsibility for the paper as a whole.

Data sharing statement: We are not able to share data because the data is proprietary.

All authors attest to meeting the four ICMJE.org authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding and support: By *Annals'* 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). JMP has received payments from CSL Behring, Medtronic, Abbott Point of Care, and Astra-Zeneca for unrelated work. The rest of the authors of the paper report no such relationships. This study did not receive any funding.

Publication dates: Received for publication May 5, 2024. Revisions received October 7, 2024, and January 8, 2025. Accepted for publication February 5, 2025.

REFERENCES

1. Croskerry P, Sinclair D. Emergency medicine: a practice prone to error? *CJEM*. 2001;3:271-276.
2. Laxmisan A, Hakimzada F, Sayan OR, et al. The multitasking clinician: decision-making and cognitive demand during and after team handoffs in emergency care. *Int J Med Inform*. 2007;76:801-811.
3. Fordyce J, Blank FS j, Pekow P, et al. Errors in a busy emergency department. *Ann Emerg Med*. 2003;42:324-333.
4. Anjum O, Yadav K, Chhabra S, et al. Definitions and factors associated with emergency physician productivity: a scoping review. *CJEM*. 2023;25:314-325.
5. Oskvarek JJ, Zocchi MS, Black BS, et al. Emergency department volume, severity, and crowding since the onset of the coronavirus disease 2019 pandemic. *Ann Emerg Med*. 2023;82:650-660.
6. Pines JM, Hilton JA, Weber EJ, et al. International perspectives on emergency department crowding. *Acad Emerg Med*. 2011;18:1358-1370.
7. Janke AT, Melnick ER, Venkatesh AK. Hospital occupancy and emergency department boarding during the COVID-19 pandemic. *JAMA Netw Open*. 2022;5:e2233964.
8. Akbar S, Radeos MS, Yang A, et al. 403: Impact of emergency medicine residents on attending physician productivity: a case-control study. *Ann Emerg Med*. 2007;50:S127.
9. Clinkscales JD, Fesmire FM, Hennings JR, et al. The effect of emergency medicine residents on clinical efficiency and staffing requirements. *Acad Emerg Med*. 2016;23:78-82.
10. Arya R, Salovich DM, Ohman-Strickland P, et al. Impact of scribes on performance indicators in the emergency department. *Acad Emerg Med*. 2010;17:490-494.
11. Walker KJ, Ben-Meir M, Phillips D, et al. Medical scribes in emergency medicine produce financially significant productivity gains for some, but not all emergency physicians. *Emerg Med Australas*. 2016;28:262-267.
12. Pines JM, Zocchi MS, Ritsema T, et al. The impact of advanced practice provider staffing on emergency department care: productivity, flow, safety, and experience. *Acad Emerg Med*. 2020;27:1089-1099.
13. Joseph JW, Davis S, Wilker EH, et al. Modelling attending physician productivity in the emergency department: a multicentre study. *Emerg Med J*. 2018;35:317-322.
14. Parwani V, Thomas M, Rothenberg C, et al. Balancing quality and utilization: emergency physician level correlation between 72 h returns, admission, and CT utilization rates. *Am J Emerg Med*. 2021;48:365-366.
15. Pines JM, Zocchi MS, De Maio VJ, et al. The effect of operational stressors on emergency department clinician scheduling and patient throughput. *Ann Emerg Med*. 2020;76:646-658.
16. Nikolla DA, Zocchi MS, Pines JM, et al. Four- and three-year emergency medicine residency graduates perform similarly in their first year of practice compared to experienced physicians. *Am J Emerg Med*. 2023;69:100-107.
17. Kindermann DR, Mutter RL, Cartwright-Smith L, et al. Admit or transfer? The role of insurance in high-transfer-rate medical conditions in the emergency department. *Ann Emerg Med*. 2014;63:561-571.e8.
18. Li J, Pryor S, Choi B, et al. Reasons for interfacility emergency department transfer and care at the receiving facility. *Pediatr Emerg Care*. 2020;36:95-100.
19. Simon EL, Morra A, Septaric K, et al. Do emergency department transfers require specialist consultation or admission? *JEM Rep*. 2023;2:100035.
20. Clinical Classifications Software Refined (CCSR) for ICD-10-CM Diagnoses. Accessed November 22, 2021. https://www.hcup-us.ahrq.gov/toolssoftware/ccsr/dxccsr.jsp
21. Abualenain J, Frohna WJ, Smith M, et al. The prevalence of quality issues and adverse outcomes among 72-hour return admissions in the emergency department. *J Emerg Med*. 2013;45:281-288.
22. ACEP Now. By the numbers: current emergency medicine specialty statistics. Accessed August 7, 2024. https://www.acepnow.com/article/by-the-numbers-current-emergency-medicine-specialty-statistics/
23. Vella KM, Hall AK, van Merrienboer JJG, et al. An exploratory investigation of the measurement of cognitive load on shift: application of cognitive load theory in emergency medicine. *AEM Educ Train*. 2021;5:e10634.
24. Salthouse TA, Babcock RL, Shaw RJ. Effects of adult age on structural and operational capacities in working memory. *Psychol Aging*. 1991;6:118-127.
25. Salthouse TA, Mitchell DR, Skovronek E, et al. Effects of adult age and working memory on reasoning and spatial abilities. *J Exp Psychol Learn Mem Cogn*. 1989;15:507-516.
26. Eva KW. The aging physician: changes in cognitive processing and their impact on medical practice. *Acad Med*. 2002;77:S1-S6.
27. Goldberg R, Thomas H, Penner L. Issues of concern to emergency physicians in pre-retirement years: a survey. *J Emerg Med*. 2011;40:706-713.
28. Binder W, Abrahams CO, Fox JM, et al. The age-old question: thematic analysis of focus groups on physician experiences of aging in emergency medicine. *J Am Coll Emerg Physicians Open*. 2021;2:e12499.
29. Carlson JN, Foster KM, Pines JM, et al. Provider and practice factors associated with emergency physicians being named in a malpractice claim. *Ann Emerg Med*. 2018;71:157.
30. Miyawaki A, Jena AB, Burke LG, et al. Association between emergency physician's age and mortality of medicare patients aged 65 to 89 years after emergency department visit. *Ann Emerg Med*. 2023;82:301-312.
31. Li CJ, Syue YJ, Tsai TC, et al. The impact of emergency physician seniority on clinical efficiency, emergency department resource use, patient outcomes, and disposition accuracy. *Medicine (Baltimore)*. 2016;95:e2706.
32. Jefferson L, Bloor K, Birks Y, et al. Effect of physicians' gender on communication and consultation length: a systematic review and meta-analysis. *J Health Serv Res Policy*. 2013;18:242-248.
33. Rondeau KV, Francescutti LH, Cummings GE. Health promoting attitudes and behaviors of emergency physicians: exploring gender differences. *J Health Organ Manag*. 2006;20:269-284.
34. Hsuan C, Segel JE, Hsia RY, et al. Association of emergency department crowding with inpatient outcomes. *Health Serv Res*. 2023;58:828-843.
35. Singer AJ, Thode HC, Viccellio P, et al. The association between length of emergency department boarding and mortality. *Acad Emerg Med*. 2011;18:1324-1329.
36. Pines JM, Hollander JE. Emergency department crowding is associated with poor care for patients with severe pain. *Ann Emerg Med*. 2008;51:1-5.
37. Pines JM, Iyer S, Disbot M, et al. The effect of emergency department crowding on patient satisfaction for admitted patients. *Acad Emerg Med*. 2008;15:825-831.
38. Pielsticker S, Whelan L, Arthur AO, et al. Identifying patient door-to-room goals to minimize left-without-being-seen rates. *West J Emerg Med*. 2015;16:611-618.
39. Smalley CM, Meldon SW, Simon EL, et al. Emergency department patients who leave before treatment is complete. *West J Emerg Med*. 2021;22:148-155.
40. Sun BC, Hsia RY, Weiss RE, et al. Effect of emergency department crowding on outcomes of admitted patients. *Ann Emerg Med*. 2013;61:605-611.e6.