American Journal of Emergency Medicine 36 (2018) 1865–1869

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Brief Report

Are testers also admitters? Comparing emergency physician resource utilization and admitting practices

Nicole R. Hodgson, MD [a,b,*], Souroush Saghafian, PhD [c], Lanyu Mi, MS [a], Matthew R. Buras, MS [a], Eric D. Katz, MD [b], Jesse M. Pines, MD MBA [d], Leon Sanchez, MD [e], Scott Silvers, MD [f], Steven A. Maher, MD [a], Stephen J. Traub, MD [a]

[a] Department of Emergency Medicine, Mayo Clinic Arizona, Phoenix, AZ, USA
[b] Department of Emergency Medicine, District Medical Group-Maricopa Integrated Health Systems, Phoenix, AZ, USA
[c] Harvard Kennedy School, Harvard University, Cambridge, MA, USA
[d] Department of Emergency Medicine and Health Policy & Management, George Washington University, Washington, DC, USA
[e] Department of Emergency Medicine, Beth Israel Deaconess Medical Center, Boston, MA, USA
[f] Department of Emergency Medicine, Mayo Clinic Florida, Jacksonville, FL, USA

ARTICLE INFO

Article history:
Received 1 May 2018
Received in revised form 30 June 2018
Accepted 20 July 2018

Keywords:
Resource utilization
Provider variability
Emergency medicine

ABSTRACT

Objective: To describe the relationship between emergency department resource utilization and admission rate at the level of the individual physician.
Methods: Retrospective observational study of physician resource utilization and admitting data at two emergency departments. We calculated observed to expected (O/E) ratios for four measures of resource utilization (intravenous medications and fluids, laboratory testing, plain radiographs, and advanced imaging studies) as well as for admission rate. Expected values reflect adjustment for patient- and time-based variables. We compared O/E ratios for each type of resource utilization to the O/E ratio for admission for each provider. We report degree of correlation (slope of the trendline) and strength of correlation (adjusted R^2 value) for each association, as well as categorical results after clustering physicians based on the relationship of resource utilization to admission rate.
Results: There were statistically significant positive correlations between resource utilization and physician admission rate. Physicians with lower resource utilization rates were more likely to have lower admission rates, and those with higher resource utilization rates were more likely to have higher admission rates.
Conclusions: In a two-facility study, emergency physician resource utilization and admission rate were positively correlated: those who used more ED resources also tended to admit more patients. These results add to a growing understanding of emergency physician variability.

1. Introduction

Emergency physicians (EPs) differ with regard to resource utilization [1, 2] and admission rate [3, 4]. We sought to determine the relationship, if any, between the rate of utilization of specific resources (intravenous medications and fluids, laboratory tests, plain radiographs, and advanced imaging studies) and admission rate.

2. Methods

2.1. Study design and setting

This retrospective analysis of routinely gathered emergency department (ED) operational data was a two-site quality improvement study and identified as exempt from our institutional review board process.

Neither site has an Emergency Medicine training program or a Fast Track. Both sites are staffed by residency-trained EPs, utilize a rotational patient assignment system [5], and have resident physicians from other services working in the department who assist in evaluating ~5% of patients. Additional site characteristics are noted in Table 1.

* Corresponding author at: Department of Emergency Medicine, Mayo Clinic Arizona, Phoenix, AZ, USA.
E-mail address: Hodgson.Nicole@Mayo.edu (N.R. Hodgson).

https://doi.org/10.1016/j.ajem.2018.07.041
0735-6757/

Table 1
Site characteristics.

Site	City	State	Census[a]	Rooms	Hallway Bays	NP/PA used	ED observation
1	Phoenix	AZ	34,000	24	9	None	No
2	Jacksonville	FL	24,500	22	12	One	Yes[b]

[a] Annual census rounded to nearest 500 visits.
[b] At Site 2, ~4% of patients were placed into ED observation status.

2.2. Measurements

We analyzed visits between October 1, 2015 and September 30, 2017, eliminating those who left without being seen (LWBS), those for whom no physician was assigned in the electronic medical record (EMR), and those seen by low-volume providers (<500 patient visits during the study period, which has been used as a threshold for exclusion in similar papers [6]).

We measured patient age in years, assigned sex based on patient declaration, and categorized race as white versus other. Nurses assigned Emergency Severity Index (ESI) scores in standard (1–5) fashion. Time of day was categorized by shift: day (07:00–14:59), evening (15:00–22:59), or night (23:00–06:59). Days of the week were aggregated as weekday vs. weekend. Season was categorized as Winter (January–March), Spring (April–June), Summer (July–September) and Fall (October–December). Study year 1 was October 1, 2015 to September 30, 2016; year 2 was October 1, 2016 to September 30, 2017.

Both sites utilized a common EMR and provider order entry system (Cerner®; Kansas City, MO).

Definitions of intravenous medications and fluids, laboratory testing, plain radiography, and advanced imaging were identical at both sites. We defined intravenous medications and fluids as the number of unique orders for these items that were placed per visit. We defined laboratory testing as the number of tests resulted, not number of orders placed. For example, the order for a basic metabolic panel generates results for 8 items; the laboratory testing value for a basic metabolic panel was therefore 8. We defined plain radiography as the number of x-ray studies ordered per visit, not number of specific films obtained; the plain radiography value of a 3-view plain radiograph of the wrist was therefore 1. We defined advanced imaging studies as formal computerized tomography (CT), ultrasound and magnetic resonance imaging studies; bedside ultrasound tests performed by EPs were not included. We defined admission as being hospitalized (either as a full admission or in observation status) or placed into ED observation status.

2.3. Statistics

We calculated the observed per-visit rate of each type of resource utilization for each physician. We also calculated an observed admission rate for each physician, which we defined as number of admissions/number of visits seen. Adjusted by patient (age, sex, race, and ESI score) and time (shift, day of week, season, and study year) characteristics, we determined an expected value for each visit for resource utilization using general Poisson regression and separately for admission using logistic regression. We calculated the mean of individual expected values for all visits seen by a given physician to determine that physician's expected rates. We then derived the observed/expected ratio (O/E) for each physician.

We report mean, standard deviation (SD), median, interquartile range (IQR) and range for O/E resource utilization and admission rates. We created scatter plots with fitted linear regression lines to examine the correlation between each of the four categories of resource utilization and admission rate. For each regression analysis, we determined slope (degree of association) and adjusted R^2 (strength of association) of the line of best fit.

For categorical associations, we classified physicians as "low" (O/E < 1), or "high" (O/E > 1). We then divided physicians into four groups based on their resource utilization rate/admission rate (low/low, high/low, low/high, high/high). We calculated the odds ratio for low resource utilization O/E between low versus high admission O/E. Weighted Kappa coefficients of pairwise association groups based on resource utilization/admission were calculated and tested.

3. Results

We report patient inclusion and elimination profiles in Table 2 and patient characteristics in Table 3. We report raw data for resource utilization and admission in Table 4. We report O/E ratios for resource utilization and admission in Table 5.

We present graphical relationships of per-physician resource utilization O/E ratios vs. admission O/E ratios in Fig. 1. Regression lines are shown for each of the measurements versus admission rate, surrounded by the 95% confidence interval of that line. Statistics for the line of best fit are provided above each graph. Average decile values (grouped by admission rate)—and not physician-specific data—are overlaid on each graph for context. All per-physician resource utilization measures had statistically significant positive correlations with admission.

Categorical results are reported in Table 6. EPs with low resource utilization were statistically more likely to have low admission rates and those with high resource utilization were more likely to have high admission rates in all categories except plain radiography.

4. Discussion

4.1. Main discussion

There were three plausible a priori hypotheses regarding the relationship between resource utilization and admission rate: they are independent (the null hypothesis), negatively correlated (perhaps because increased resource utilization gives EPs sufficient reassurance to discharge), or positively correlated (perhaps because EP tendencies that increase resource utilization drive the decision to admit). Our findings support the latter.

We found a significant relationship at the level of the individual physician between each of four ED resource utilization rates and admission rate (Fig. 1). We also found that physicians were more likely to have a consistent resource utilization and admission pattern (below average for both or above average for both) for all resources other than plain radiography (Table 6).

Taken in the aggregate, we believe our results suggest that, for a given patient encounter, resource utilization and admission decisions may reflect provider approach in addition to patient presentation.

Our findings are consistent with those of others. A preliminary communication found a positive correlation between CT utilization and admission rate [7]. Another study found a positive correlation between acute gastroenteritis-related testing and admission, concluding that pediatric EPs displayed a consistent high-resource or low-resource utilization tendency [1]. Previous studies have examined EP variation with regard to specific orders (such as CT scans [2] or admission [4]), but our study attempts to determine whether the physicians who are higher utilizers of ED resources are the same physicians who admit more patients. While our results collectively suggest that the propensity to utilize resources and admit patients may be an inherent physician practice characteristic, our data offer no insight into how such a propensity might develop. Previous studies suggested that both risk-aversion [8] and malpractice fears [9] may increase ordering behavior in specific clinical situations for EPs; if so, it is logical that resource utilization and admitting behavior may track together at the level of individual physician.

If risk-aversion and malpractice fears drive higher utilization, one mitigation strategy may be to integrate decision support into the EMR,

Table 2
Patient inclusion and elimination profile.

Site	Total visits	LWBS	No physician	Low-volume provider	Analyzed	Analyzed as % of total	Providers
1	67,847	376	329	2524	64,618	95.2%	24
2	58,648	807	2338[a]	28	55,475	94.6%	19

[a] At Site 2, "No physician" includes patients primarily assigned to a physician assistant.

to encourage high-utilizing EPs to safely and comfortably decrease resource utilization. One study demonstrated that such support decreased CT orders in EPs with high CT utilization rates [10]. Departmental protocols might help individual physicians feel confident employing evidence-based guidelines to decrease resource utilization where appropriate.

Our findings add to a growing understanding of EP variability. Laboratory utilization [1], utilization of advanced imaging [2], and admission rate [4] have all been shown to vary significantly between EPs; we confirm these findings and describe additional variation in the use of intravenous medication and fluid administration and the use of plain radiography.

4.2. Limitations

Our retrospective observational approach establishes correlation, but not causation.

Patient variation could dramatically impact expected rates of resource utilization or admission. The rotational assignment system in place at each site eliminates physician "cherry picking" (a known phenomenon [11]), and we further controlled for variation by controlling for patient- and time-based factors. Nonetheless, our model almost certainly fails to account for other important factors, both known and unknown. For example, adjusting for chief complaint may have improved our confidence that our patient populations were similar; unfortunately, this was impractical at our facility given the free text nature of chief complaints in our EMR. As noted above, however, our patients are algorithmically assigned via a rotational assignment system, such that the proportion of each chief complaint (or other characteristic) assigned to each physician should be similar over time, which should help mitigate this and similar issues.

We attribute orders and decisions to the first EP who evaluated the patient, although nurses and residents may place orders on the physician's behalf and consultants may place orders as well. If a second physician takes over care (such as at shift sign-out), he or she may order tests or make the admission decision. The operating culture at both sites strongly encourages finishing encounters (including disposition) prior to transfer of care, which likely limits any "second physician" effect. We also note that resident, nurse, or second-physician effects would be more likely to attenuate, not exaggerate, the differences we found.

Site 2 utilizes ED observation status, whereas Site 1 does not. We categorized ED observation patients as admitted rather than discharged, as ED observation often reflects a perceived need for more resources than could be provided in the ED visit. We acknowledge, however, that ED observation is a different type of resource utilization than hospitalization.

Both sites are part of one system, serving an atypical patient population (one enriched for oncology and transplant patients). This may limit the generalizability of our results.

We did not control for daily volume or bed availability. Anecdotally, EPs at both sites do not alter resource utilization or admission decisions based on bed availability, and all physicians at both sites are salaried employees with no financial incentive for increased throughput. We believe EPs would be affected equally by volume fluctuations and boarding issues given our relatively long timeframe but note that individual response to increased volume may vary.

We report degree and strength of associations but do not present scatterplots of individual physician data. We believed that such a granular level of reporting would place an inordinate amount of data into a public forum. We therefore present decile data (rather than physician-specific data) for context on the appropriate figures. While we acknowledge this as a limitation of our data presentation, we stand by our approach.

In this study, we sought only to determine the physician-level relationship between resource utilization and admission rate. Importantly, our work did not look at any measures of process or quality; it is possible that physicians with greater rates of resource utilization have superior patient outcomes. For example, we did not investigate whether EPs with O/E ratios of >1 had different rates of process outcomes, such as lower rates of 72 h returns with admission, compared to EPs with O/E ratios of lower than 1. An EP who we categorized in this study as a relatively high utilizer of ED resources may in fact use fewer hospital resources by expediting and improving outpatient care or by having fewer ED return visits. He or she may also have fewer missed diagnoses and improved quality markers. A more extensive ED work-up may allow for a shorter inpatient stay, decreasing overall hospital resource utilization. In this brief report, we attempt only to describe the relationship between testing and admission.

Table 3
Patient characteristics.

Characteristic	Site 1 N = 64,618	Site 2 N = 55,475
Sex		
Female (%)	34,467 (53.3%)	30,494 (55.0%)
Age		
Mean (SD)	58.2 (21.05)	57.2 (21.45)
ESI (%)		
1	678 (1.1%)	774 (1.4%)
2	12,855 (20.0%)	10,425 (18.8%)
3	43,142 (67.0%)	35,080 (63.3%)
4	7201 (11.2%)	8858 (16.0%)
5	559 (0.9%)	253 (0.5%)

Age in years.
ESI = Emergency Severity Index.

Table 4
Raw data for resource utilization and admission per visit.

	Range	Mean (SD)	Median	IQR
Site 1				
Resource utilization				
IV Medications/fluids	0–21	1.5 (2.09)	0	0–3
Laboratory tests	0–284	25.7 (20.64)	26	0–43
Plain radiography	0–9	0.5 (0.70)	0	0–1
Advanced imaging	0–8	0.4 (0.69)	0	0–1
Admission (0/1)	0–1	0.3 (0.47)	0	0–1
Site 2				
Resource utilization				
IV Medications/fluids	0–30	1.5 (2.02)	1	0–3
Laboratory tests	0–409	25.9 (21.39)	26	0–38
Plain radiography	0–9	0.6 (0.73)	0	0–1
Advanced imaging	0–8	0.4 (0.60)	0	0–1
Admission (0/1)	0–1	0.3 (0.47)	0	0–1

IV: Intravenous.
SD: Standard deviation.
IQR: Interquartile range.
Admission: 0 = not admitted, 1 = admitted.
Resource utilization reflects average number of resources utilized per visit.

Table 5
Observed/expected ratios.

	Site 1 (24 physicians)		Site 2 (19 physicians)		Combined (43 physicians)	
	Range	IQR	Range	IQR	Range	IQR
Resource utilization						
IV Medications/fluids	0.71–1.29	0.89–1.10	0.80–1.23	0.91–1.08	0.71–1.29	0.91–1.09
Laboratory tests	0.74–1.34	0.92–1.08	0.87–1.12	0.96–1.06	0.74–1.34	0.94–1.07
Plain radiography	0.74–1.46	0.90–1.08	0.83–1.28	0.95–1.04	0.74–1.46	0.93–1.05
Advanced imaging	0.66–1.36	0.85–1.19	0.86–1.26	0.93–1.07	0.66–1.36	0.89–1.12
Admission rate	0.82–1.30	0.90–1.11	0.84–1.18	0.88–1.10	0.82–1.30	0.89–1.10

IQR: Interquartile range.

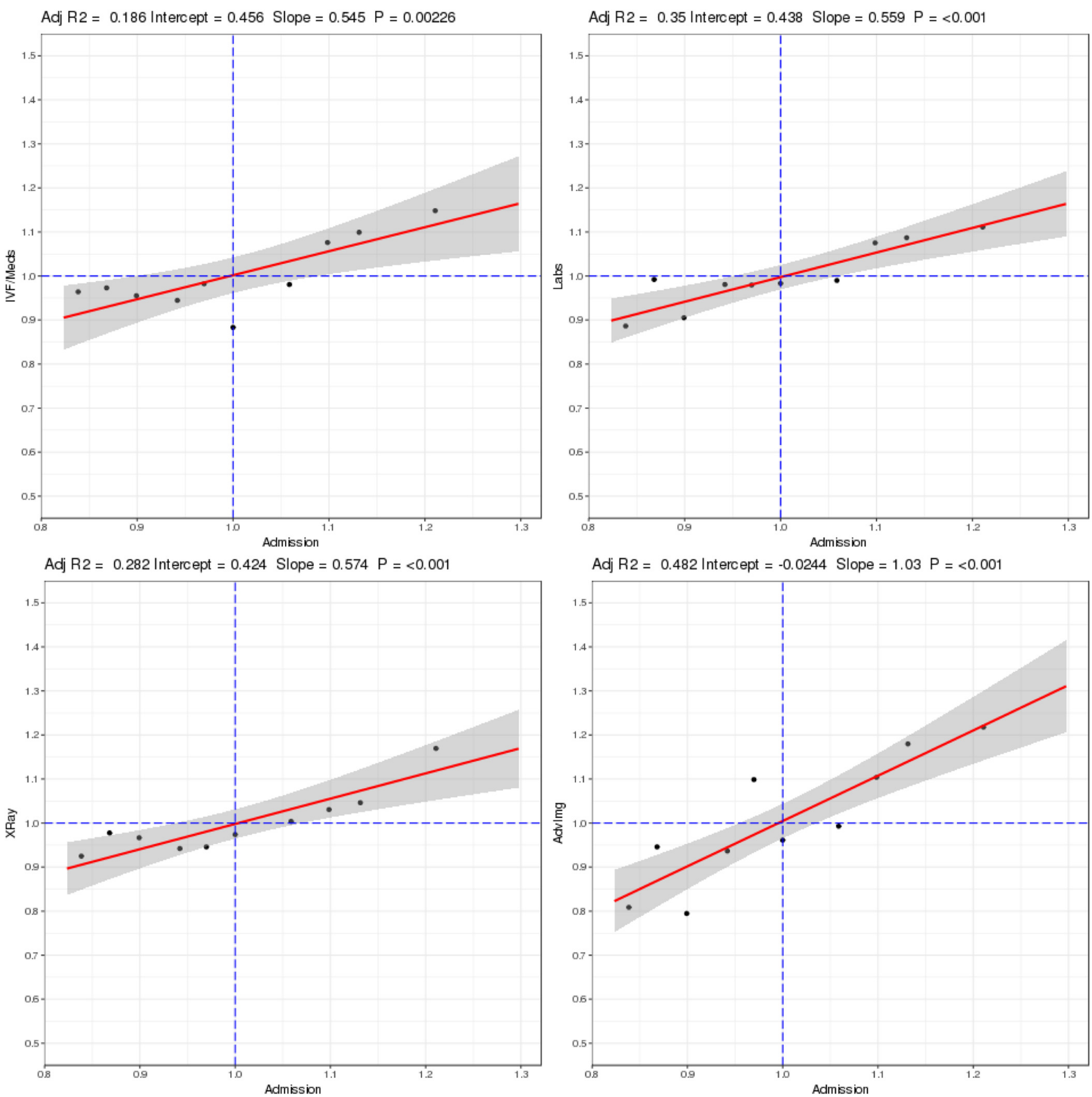

Fig. 1. Observed/expected resource utilization rates vs. observed/expected admission rates. X axis shows provider O/E ratio for admission. Y axis shows provider O/E ratio for IV medications and fluids (IVF/Meds), laboratory studies (Labs), plain imaging (XRay) and advanced imaging (AdvImg). Shaded area around the regression line represents the 95% confidence interval of the line. Average decile data (grouped by admission rate) overlaid on graph for context.

Table 6
Categorical groupings of physicians.

A. Raw data

Specific resource	Resource utilization rate/admission rate			
	Low/low	High/low	Low/high	High/high
Laboratory tests	17	7	7	12
IV Medications/fluids	15	5	9	14
Plain radiographs	14	8	10	11
Advanced imaging	18	4	6	15

Low = O/E ratio < 1.
High = O/E ratio > 1.

B. Odds ratios of characterization as low/low or high/high vs. low/high or high/low

Specific resource	Odds ratio	95% Confidence interval
Laboratory tests	4.2	1.2–15.0
IV Medications/fluids	4.7	1.3–17.4
Plain radiographs	1.9	0.6–6.5
Advanced imaging	11.3	2.7–47.4

C. Weighted kappa coefficients

O/E comparisons	Number of agreement (percent)	Kappa (weighted)	P value
Advanced imaging vs. IV medications/fluids	31 (72.1%)	0.80 (0.70, 0.90)	<0.0001
Advanced imaging vs. laboratory tests	35 (81.4%)	0.87 (0.78, 0.95)	<0.0001
Advanced imaging vs. plain radiographs	27 (62.8%)	0.73 (0.62, 0.84)	<0.0001
IV medications/fluids vs. laboratory tests	29 (67.4%)	0.76 (0.66, 0.87)	<0.0001
IV medications/fluids vs. plain radiographs	33 (76.7%)	0.83 (0.73, 0.93)	<0.0001
Laboratory tests vs. plain radiographs	27 (62.8%)	0.72 (0.61, 0.84)	<0.0001

4.3. Conclusions

EPs who order more intravenous fluids and medications, laboratory studies, x-rays, and advanced imaging studies are also more likely to admit patients to the hospital. Future work may help to clarify the drivers of this relationship, determine whether there is an association between rates of resource utilization and quality of care, and use these findings to develop optimal mechanisms to improve ED resource utilization.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declarations of interest

None.

References

[1] Tavarez MM, Ayers B, Jeong JH, et al. Practice variation and effects of e-mail–only performance feedback on resource use in the emergency department. Acad Emerg Med 2017;24(8):948–56. https://doi.org/10.1111/acem.13211.
[2] Levine MB, Moore AB, Franck C, et al. Variation in use of all types of computed tomography by emergency physicians. Am J Emerg Med 2013;31(10):1437–42. https://doi.org/10.1016/j.ajem.2013.07.003.
[3] Pines JM, Galarraga JE, Granvosky M, et al. How (ED) admission decisions differ when the same physician works in two different emergency department. Am J Emerg Med 2017;35(7):970–3. https://doi.org/10.1016/j.ajem.2017.01.067.
[4] Khojah I, Li S, Luo Q, et al. The relative contribution of provider and ED-level factors to variation among the top 15 reasons for ED admission. Am J Emerg Med 2017;35(9):1291–7. https://doi.org/10.1016/j.ajem.2017.03.074.
[5] Traub SJ, Stewart CF, Didehban R, et al. Emergency department rotational patient assignment. Ann Emerg Med 2016;67(2):206–15. https://doi.org/10.1016/j.annemergmed.2015.07.008.
[6] Abualenain J, Frohna WJ, Shesser R, et al. Emergency department physician-level and hospital-level variation in admission rates. Ann Emerg Med 2013;61(6):638–43. https://doi.org/10.1016/j.annemergmed.2013.01.016.
[7] Shanin D, Ulrich A, Robinson C, et al. Scan, admit, or both? Is there a correlation between admission rate and computed tomography utilization? Ann Emerg Med 2017;70(4S):S8–9. https://doi.org/10.1016/j.annemergmed.2017.07.042.
[8] Pines JM, Hollander JE, Isserman JA, et al. The association between physician risk tolerance and imaging use in abdominal pain. Am J Emerg Med 2009;27(5):552–7. https://doi.org/10.1016/j.ajem.2008.04.031.
[9] Katz DA, Williams GC, Brown RL, et al. Emergency physicians' fear of malpractice in evaluating patients with possible acute cardiac ischemia. Ann Emerg Med 2005;46(6):525–33. https://doi.org/10.1016/j.annemergmed.2005.04.016.
[10] Bookman K, West D, Ginde A, et al. Embedded clinical decision support in electronic health record decreases use of high cost imaging in the emergency department: EmbED study. Acad Emerg Med 2017;24(7):1–7. https://doi.org/10.1111/acem.13195.
[11] Patterson BW, Batt RJ, Wilbanks MD, et al. Cherry picking patients: examining the interval between patient rooming and resident self-assignment. Acad Emerg Med 2016;23(6):679–84. https://doi.org/10.1111/acem.12895.