Internal and Emergency Medicine (2022) 17:829–837
https://doi.org/10.1007/s11739-021-02796-8

EM - ORIGINAL

The presentations/physician ratio predicts door-to-physician time but not global length of stay in the emergency department: an Italian multicenter study during the SARS-CoV-2 pandemic

Simone Vanni[1] · Paola Bartalucci[1] · Ubaldo Gargano[1] · Alessandro Coppa[1] · Gianfranco Giannasi[2] · Peiman Nazerian[3] · Barbara Tonietti[4] · Roberto Vannini[5] · Michele Lanigra[6] · Fabio Daviddi[7] · Alessio Baldini[8] · Stefano Grifoni[3] · Simone Magazzini[8]

Received: 25 January 2021 / Accepted: 14 June 2021 / Published online: 22 July 2021

Abstract

To investigate the effects of the dramatic reduction in presentations to Italian Emergency Departments (EDs) on the main indicators of ED performance during the SARS-CoV-2 pandemic. From February to June 2020 we retrospectively measured the number of daily presentations normalized for the number of emergency physicians on duty (presentations/physician ratio), door-to-physician and door-to-final disposition (length-of-stay) times of seven EDs in the central area of Tuscany. Using the multivariate regression analysis we investigated the relationship between the aforesaid variables and patient-level (triage codes, age, admissions) or hospital-level factors (number of physician on duty, working surface area, academic vs. community hospital). We analyzed data from 105,271 patients. Over ten consecutive 14-day periods, the number of presentations dropped from 18,239 to 6132 (−67%) and the proportion of patients visited in less than 60 min rose from 56 to 86%. The proportion of patients with a length-of-stay under 4 h decreased from 59 to 52%. The presentations/physician ratio was inversely related to the proportion of patients with a door-to-physician time under 60 min (slope −2.91, 95% CI −4.23 to −1.59, $R^2 = 0.39$). The proportion of patients with high-priority codes but not the presentations/physician ratio, was inversely related to the proportion of patients with a length-of-stay under 4 h (slope −0.40, 95% CI −0.24 to −0.27, $R^2 = 0.36$). The variability of door-to-physician time and global length-of-stay are predicted by different factors. For appropriate benchmarking among EDs, the use of performance indicators should consider specific, hospital-level and patient-level factors.

Keywords Emergency Department · Door-to-physician · Length-of-stay · Performance indicator · Community hospital

✉ Simone Vanni
simone2.vanni@uslcentro.toscana.it

[1] Emergency Medicine Unit, Ospedale San Giuseppe, Emergency Department of Azienda USL Toscana Centro, Empoli, Italy

[2] Emergency Medicine Unit, Ospedale San Giovanni di Dio, Emergency Department of Azienda USL Toscana Centro, Firenze, Italy

[3] Department of Emergency Medicine, Azienda Ospedaliero-Universitaria Careggi, Firenze, Italy

[4] Department of Health and Management, Azienda Ospedaliero-Universitaria Careggi, Firenze, Italy

[5] Emergency Medicine Unit, Ospedale del Mugello, Emergency Department of Azienda USL Toscana Centro, Borgo San Lorenzo, Italy

[6] Emergency Medicine Unit, Ospedale Santa Maria Nuova, Emergency Department of Azienda USL Toscana Centro, Firenze, Italy

[7] Emergency Medicine Unit, Ospedale Santi Cosa e Damiano, Emergency Department of Azienda USL Toscana Centro, Pescia, Italy

[8] Emergency Medicine Unit, Ospedale Santo Stefano, Emergency Department of Azienda USL Toscana Centro, Prato, Italy

Introduction

Performance indicators are often used for benchmark analysis among different Emergency Departments (EDs). Two of the most frequently used are time to first medical visit (door-to-physician) and time to final disposition (length-of-stay) [1]. However, the performance of the different EDs is usually compared without considering their functional or structural differences, or, as reported in recent literature, it only considers patient-level factors and not hospital-level factors such as the number of working physicians or the treatment surface area [2]. Moreover, well-designed, multicentre and properly dimensioned studies on major determinants of these performance indicators, have been conducted almost exclusively in academic hospitals [3–5], thus limiting the generalizability of their results.

During the first wave of SARS-CoV-2 pandemic, for a short period of time we observed profound changes in the organization of emergency services [6], to cope with the increase in patients presented with coronavirus disease 2019 (COVID-19). The increase of these patients was associated with a dramatic reduction in presentations for other reasons [7, 8], in particular, traumatic and surgical diseases [9, 10], which determined a net absolute decrease in the total presentations to the EDs [6]. This exceptional phenomenon prompted us to evaluate how ED performance changes during significant changes in the patient presentations. The aim of this study was to investigate not only whether two of the main indicators of ED performance, door-to-physician time and global length-of-stay, were influenced by the change in the patient presentations, but also how and to what extent patient-level and hospital-level factors, in turn, may have influenced these indicators.

Methods

Study design

This is a retrospective, multicentre cohort study, conducted during the first wave SARS-CoV-2 pandemic in central Tuscany, Italy. The study involved 7 EDs, 6 level-two (Spoke, reported as centre A to F) and 1 level-three (Hub, reported as centre G), teaching ED. All EDs used the same electronic clinical charts, named "First-aid" (Dedalus, Florence, Italy) and anonymous data were collected by a specific statistical software "BI4H" (Dedalus, Florence, Italy). Because the first COVID-19 cases in central Tuscany were diagnosed at beginning of March and significantly declined after the last week of May 2020, we chose to conduct the observation from at least 2 weeks before the start (February 3rd) until two weeks after the decline (June 21st) in order to have a sufficient baseline time to be compared before and after the first pandemic wave. We think this approach was better than a direct comparison with the same period of the 2019 because we were more confident that hospital-level factors were the same during all the study period. Data were grouped in ten consecutive fourteen-day periods. In each period, we considered the following data from all the participating centres: number of presentations, age, triage code, door-to-physician time, door-to-final disposition time, number of hospital admissions, number of patients that left the ED without being seen (left without being seen), number of patients that returned to the ED for another visit within 72 h (return-to-ED within 72 h), number of physicians on duty and treatment surface area. The treatment area was calculated starting from the floorplans of the various EDs, excluding the rooms for meetings and study rooms or other non-healthcare activities and approximated to hundreds of square meters.

This retrospective study was notified to the local ethical committee (N°19,830). The study was conducted in accordance with the declaration of Helsinki. The authors have no conflict of interest to declare.

Terms and measurements

Triage codes were assigned by certified nurses according to the regional protocol n° 807/2017 used in all the participating EDs. The regional triage protocol consists of five codes: code 1 = emergency (no wait), code 2 = undelayable urgency (suggested waiting time less than 15 min), code 3 = delayable urgency (suggested waiting time less than 60 min), code 4 = minor urgency (suggested waiting time less than 120 min), code 5 = no urgency (suggested waiting time less than 240 min). The number of presentations included all patients registered at the triage, including patients who left without being seen.

According to the software for the extraction of data, the time to first medical evaluation (door-to-physician) started from the beginning of the triage, as reported automatically by the electronic clinical chart, and ended when the first clinical evaluation was recorded by the attending physician in the electronic clinical chart.

Length-of-stay started from the beginning of the triage and ended when the electronic clinical charts were closed due to discharge, hospital admission, transfer to another hospital or death. Length-of-stay ended also when the patient status changed from "Visit" to "Observation". "Observation" status started after the first medical evaluation and first-line laboratory or radiological exams when the patient was transferred from the treatment area of the ED to the 48-h observation area.

We reported door-to-physician time and length-of-stay as the proportion of patients visited within 60 min after the triage and as the proportion of patients with final disposition within 4 h after the triage, because the Tuscany health system currently uses these measurements as benchmarking standards.

Return to visit within 72 h included unscheduled patients who returned to ED for any reason within 72 h after the index visit. The number of emergency physicians (EP)'s working in each centre was computed considering the number of EPs on duty during the 24 h in the ED treatment areas of the ED without taking account of those working in the observation areas. To allow a direct comparison among different centres, we normalized the number of presentations during the 24 h, counted as the number of closed clinical charts in the 24 h, by the number of EPs on duty in the same period in the emergency areas (presentations/physician ratio). Finally, we measured the proportions of codes 1, 2 and 3, the proportions of patients who left without being seen, and patients returning to the ED within the following 72 h.

All these variables were registered during each of the ten 14-day periods for all 7 centres, which resulted in having 70 point observations for each variable included in the analysis.

Statistical analysis

Continuous variables are reported as median ± inter-quartile range (IQR). Dichotomous variable are reported as proportions with a 95% confidence interval (CI). Comparisons between proportions were performed by the Chi-square test.

We included in the multivariate regression model all variables that were expected to have a plausible association with dependent variables (door-to-physician time, expressed as a proportion of patients seen within 60 min after the triage, and door-to-final disposition time, expressed as a proportion of patients with final disposition within 4 h from triage) and that reached a probability value (P) less than 0.1 at the univariate analysis. Co-linearity among independent variables was excluded before running the multivariate analysis. We chose a backward rather than forward analysis and a value of $P < 0.10$ instead of 0.05 to reduce potential bias in the selection of the variables as suggested by Sun et al. [11]. After the backward stepwise analysis, only independent variables that remained associated with the dependent variables at a significant level of P less than 0.05 were included in the final model. The multivariate analysis was performed by STATA 16.

We determined the relative weight of each variable on the dependent variable by estimating the coefficient of determination R^2. R^2 is the proportion of the variation in the dependent variable explained by the regression model and is a measure of the relevance of the independent variable on the variation of the dependent one.

Results

From 3 February to 21 June 2020, 105,271 patients with a median age of 53 years (range 0–102 years), 50.9% of whom females, arrived in the participating EDs. Triage codes 1, 2 and 3 were 1.8%, 9.1% and 48.1% of the total presentations, respectively. In the same period, 19,755 (18.8%) patients were admitted to hospital wards and 234 (0.2%) patients died in the ED. In comparison, in the same period of 2019, 174,595 patients arrived in the participating EDs (−60.3%), with an admission rate of 12.9% ($n = 22{,}579$) and an ED mortality of 0.2% ($n = 263$).

Baseline characteristics of participating centers

The participating EDs showed quite different profiles immediately before the start of the SARS-CoV-2 pandemic (period 1: from 3 to 17 February) (Table 1). The number of daily presentations ranged from 68 patients for centre A to 338 patients for centre G. Code 1 and 2 prevalence range from 6% for centre 7 to 12% for centres D and E. The admission rate ranged from 9% for centre F to 14% for centre B. The proportion of patients with a door-to-physician time under 60 min ranged from 52 to 91% and the proportion of patients with a length of stay under 4 h from 54 to 65%. Finally, each centre differed for the surface area of treatment (from 400 to 4000 m^2) and for physicians on duty in the 24 h (from 6 to 18). The presentations/physician ratio ranged from 11 to 19.

Changes during the pandemic of SARS-CoV-2

The patients' characteristics, grouped for each 14-day presentation period (from period 1 to 10), are reported in Table 2. From the first to the fourth period (16–19 March 2020), total presentations dropped from 18,223 to 6.134 (−67%) with a more evident reduction in low-priority codes (−80.5% for code 4 and 5). However, high-priority codes (code 1 and 2) also dropped by 33%. The absolute number of hospital admissions decreased (−23%), while the relative proportion of hospital admissions increased from 13 to 32% (Table 2).

In the same periods, the proportion of patients with a door-to-physician time under 60 min significantly increased from 56% (CI 95%, 55–56%) to 86% (CI 95%, 85–86%, $P < 0.001$), whereas the proportion of patients with a length of stay under 4 h slightly reduced from 59% (CI 95%, 58–60%) to 54% (CI 95%, 53–55%, $P < 0.001$) (Table 2).

Table 1 Period 1 (3–16 February 2020)

Emergency department	A		B		C		D		E		F		G		Median	IQR
Total presentations	949	(%)	4045	(%)	3141	(%)	2145	(%)	1721	(%)	1507	(%)	4731	(%)	2145	585
Code 1	6	1	71	2	30	1	23	1	21	1	20	1	55	1	23	3
Code 2	72	8	243	6	197	6	226	11	194	11	89	6	222	5	197	82
Code 3	371	39	2001	49	1453	46	1021	48	585	34	707	47	2019	43	1021	406
Code 4	470	50	1270	31	1243	40	741	35	356	21	606	40	1597	34	741	237
Code 5	27	3	451	11	200	6	128	6	421	24	75	5	834	18	200	112
Admissions	97	10	553	14	420	13	277	13	252	15	129	9	557	12	277	117
Age > 80 years	130	14	536	13	456	15	450	21	280	16	252	17	662	14	450	191
Left without being seen	31	3	21	1	116	4	77	4	70	4	74	5	203	4	74	33
Back within 72 h	42	4	177	4	158	5	89	4	86	5	63	4	88	2	88	19
Door-to-physician < 60 min	561	59	2256	56	1737	55	815	38	945	55	1368	91	2460	52	1368	521
Lenght of stay < 4 h	548	58	2214	55	1936	62	1149	54	1116	65	975	65	2850	60	1149	139
Total daily presentations	68		289		224		153		123		108		338		153	42
Surface area of treatment (m^2)	400		900		700		800		400		500		4000		700	275
Indexed surface area (m^2/patients)	6		3		3		5		3		5		12		5	1
Physician on duty in the 24 h	6		18		15		12		7		8		18		12	5
Presentations/physician ratio	11		16		15		13		18		13		19		15	2

During subsequent periods after 29 March, the total presentations progressively increased (+96% in the last period vs. period 4) and the proportion of patients with a door-to-physician time under 60 min progressively reduced (from 86 to 71% in the last period). The proportion of patients with a length of stay under 4 h rose from 54 to 61% in the last period.

Analysis of variables associated with door-to-physician time

The number of daily presentations normalized for the number of physicians on duty, was strongly and inversely related with the proportion of patients with a door-to-physician time under 60 min (Table 3). Thus, the higher the presentations/physician ratio, the longer the door-to physician time, the lower the proportion of patients with a door-to-physician time under 60 min (Fig. 1). According to this relationship, considering the best (the upper) 95% confidence interval of the slope, when more than 8 patients/physician arrived at the ED, the proportion of patients with a door-to-physician time under 60 min was expected to drop below 80%. This relationship was confirmed by multivariate analysis after adjusting for case-mix (proportions of codes 1, 2 and 3, of admitted patients and patients older than 80 years) (Table 3). We found a similar relationship (slope: −5.13, 95% CI −6.65 to −3.61) when only patients with code 3, which according to the regional standards should not wait more than 60 min, were considered.

Analysis of variables associated with length-of-stay in the EDs

During the period of observation, the length-of-stay in the EDs varied less than door-to-physician time (Table 2). Unlike the door-to-physician time, by the univariate analysis the presentations/physician ratio was positively and not negatively related to the proportion of patients with a length-of-stay under 4 h (Table 3). However, by multivariate analysis, the proportion of patients with high-priority codes (codes 1, 2 and 3), plus the treatment surface area for each presenting patient and the type of ED (academic vs community ED), but not the presentations/physician ratio, were inversely related to the proportion of patients with a door-to-final disposition time under 4 h (Table 3). Thus, as reported in Fig. 2, the higher the percentage of patients with codes 1,2 or 3, the longer the length-of-stay in the ED, the lower the proportion of patients with a length-of-stay under 4 h.

Discussion

This study showed that the presentations/physician ratio is positively related to door-to-physician time; the higher the presentation/physician ratio, the longer the door-to-physician time, the lower the proportion of patients visited in less than 60 min. Differently, after adjusting for confounding factors, we were not able to demonstrate a significant relationship between the presentations/physician ratio and the global length-of-stay in the ED, suggesting that these

Table 2 Number of presentations, patient level factors and performance indicators during the 14-day periods of observation

Consecutive periods of 14-days	1		2		3		4		5		6	
Presentations to 7 EDs	18,239		15,770		9638		6134		6153		7355	
Code 1 (%)	226	1	234	1	180	2	188	3	144	2	163	2
Code 2 (%)	1243	7	1200	8	903	9	797	13	769	12	841	11
Code 3 (%)	8157	45	7242	46	4763	49	3484	57	3378	55	3721	51
Code 4 (%)	6283	34	5281	33	2843	29	1180	29	1330	22	1707	23
Code 5 (%)	2136	12	1753	11	911	9	460	7	504	8	896	12
Admissions (%)	2285	13	2152	14	1832	19	1990	32	1823	30	1852	25
Age > 80 years (%)	2766	15	2345	15	1595	17	1189	19	1325	22	1398	19
Left without being seen (%)	522	3	547	3	254	3	111	2	87	1	146	2
Back within 72 h (%)	617	3	554	4	299	3	127	2	199	3	246	3
Door-to-physician < 60 min (%)	10,142	56	9456	60	7029	73	5257	86	5133	83	5899	80
Length of stay < 4 h (%)	10,788	59	9450	60	5874	61	3288	54	3188	52	4055	55
Consecutive periods of 14-days	7		8		9		10		Total			
Presentations to 7 EDs	8512		10,107		11,330		12,033		105,271			
Code 1 (%)	181	2	192	2	182	2	187	2	1895	2		
Code 2 (%)	852	10	926	9	986	9	1107	10	9713	9		
Code 3 (%)	4246	50	4790	47	5237	46	5565	49	51,029	8		
Code 4 (%)	2209	26	2939	29	3552	31	3736	33	31,308	30		
Code 5 (%)	992	12	1237	12	1345	12	1399	12	11,729	11		
Admissions (%)	1861	22	1962	19	1973	17	2025	18	19,755	19		
Age > 80 years (%)	1515	18	1605	16	1768	16	1928	17	17,434	17		
Left without being seen (%)	182	2	228	2	322	3	390	3	2789	3		
Back within 72 h (%)	313	4	385	4	358	3	408	4	3506	3		
Door-to-physician < 60 min (%)	6755	79	7620	75	7929	70	8008	71	73,228	70		
Length of stay < 4 h (%)	4943	58	6013	59	6773	60	6960	61	61,332	58		

ED Emergency department

Period 1 = 3–16 February, Period 2 = February 17-March 1, Period 3 = 2–15 March, Period 4 = 16–29 March, Period 5 = March 30–April 12, Period 6 = 13–16 April, Period 7 = April 27- May 10, Period 8 = 11–24 May 24, Period 9 = May 25- June 7, Period 10 = 8–21 June

two performance indicators recognize different major contributors.

That some patients will have to wait in the ED is inevitable. Many people think this may be due to an insufficient capacity of the ED, in terms of personnel, spaces or organization. As a result, government authorities and scientists in several countries have codified performance indicators of the healthcare systems, with at least two different objectives in addition to the fundamental one of the enjoyments of the highest attainable health standards for all people [5, 12]. The first is that of studying the processes of the healthcare system by comparing different models and their performances. The second is to establish common pre-determined targets to which the healthcare system should adhere. Due to this dual aspect, at times the same parameters are used as both indicator and target of the process, often without any scientific evidence supporting it. For example, in 2004, the English government introduced a regulation that 95% of all patients would have a door-to-final disposition time of no longer than 4 h in an ED [13]. Although it is known that long stays in the ED are associated with higher patient mortality and worse outcomes [14], the cut-offs of 95% no longer than 4 h was not based on any evidence or even expert opinions [15]. For this reason, recent literature has focused on performance indicators in an attempt to unravel their major determinants and their implications [16–19].

Our study is the first to investigate the effects of presentations on door-to-physician time in Italian EDs. Although door-to-physician time is considered one of the major targets of modern ED performance [1–5], very few data are available on its main predictors in large cohort studies [20, 21]. In our multicentre study, we found that the presentations/physician ratio predicted the proportion of patients visited in less than 60 min, also after adjusting for case-mix and hospital-level performance indicators. Moreover, our analysis highlighted that the presentations/physician ratio is the major determinant of door-to-physician time, accounting for nearly 40% of the overall variability among the different

Table 3 Predictors of door-to-physician and of length of stay times. Results of multivariate analysis

Dependent variable Door-to-physician within 60 min (%)	Univariate analysis			*P*	Multivariate analysis			*P*
Independent variables	Slope	95% CI	R_2		Slope	95% CI	R_2	
Code 1 + 2 + 3 (%)	0.29	0.05 to − 0.65	0.04	0.095	0.66	0.07–1.26		0.029
Admissions (%)	0.8	0.32–1.27	0.14	0.001	− 0.98	− 1.80 to − 0.16		0.020
Age of patients > 80 years (%)	− 0.04	− 0.06 to − 0.01	0.03	0.135				0.069
Left without being seen (%)	− 2.71	− 5.7 to 0.28	0.05	0.075				0.389
Back within 72 h (%)	− 1.64	− 4.48 to − 1.19	0.02	0.251				
Indexed surface area (m2/patients)	0.62	0.19 to 1.04	0.11	0.006				0.074
Presentations/physician ratio	− 2.42	− 3.25 to − 1.59	0.33	< 0.001	− 2.91	− 4.23 to − 1.59	0.39	< 0.001
Participating center (academic vs community)	− 0.08	− 1.82 to 1.67	0.00	0.928				0.912
Dependent variable Length of stay within 4 h (%)	Univariate analysis			*P*	Multivariate analysis			*P*
Independent variables	Slope	95% CI	*R*2		Slope	95% CI	*R*2	
Code 1 + 2 + 3 (%)	− 0.16	− 0.30 to 0.01	0.07	0.031	-0.4	− 0.54 to − 0.27	0.36	< 0.001
Admissions (%)	− 0.44	− 0.63 to − 0.25	0.25	0.001				0.434
Age of patients > 80 years (%)	−0.73	− 1.15 to − 0.31	0.15	0.001				0.152
Left without being seen (%)	0.92	− 0.32 to 2.17	0.03	0.147				0.532
Back within 72 h (%)	−0.51	− 1.69 to − 0.67	0.01	0.391				
Indexed surface area (m^2/patients)	−0.22	− 0.40 to − 0.04	0.08	0.016	− 0.25	− 0.39 to − 0.10		0.001
Presentations/physician ratio	0.9	0.54–1.26	0.27	< 0.001				0.182
Participating Center (academic vs community)	− 0.78	− 1.48 to − 0.09	0.07	0.028	− 1.17	− 1.72 to -0.62		< 0.001

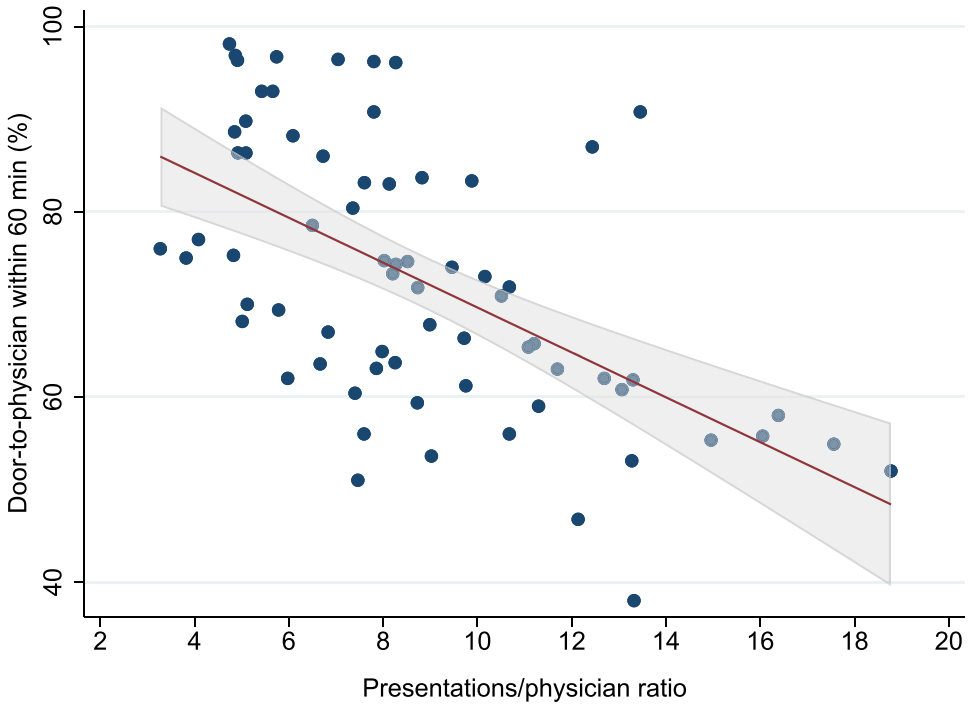

Fig. 1 Presentations/physician ratio

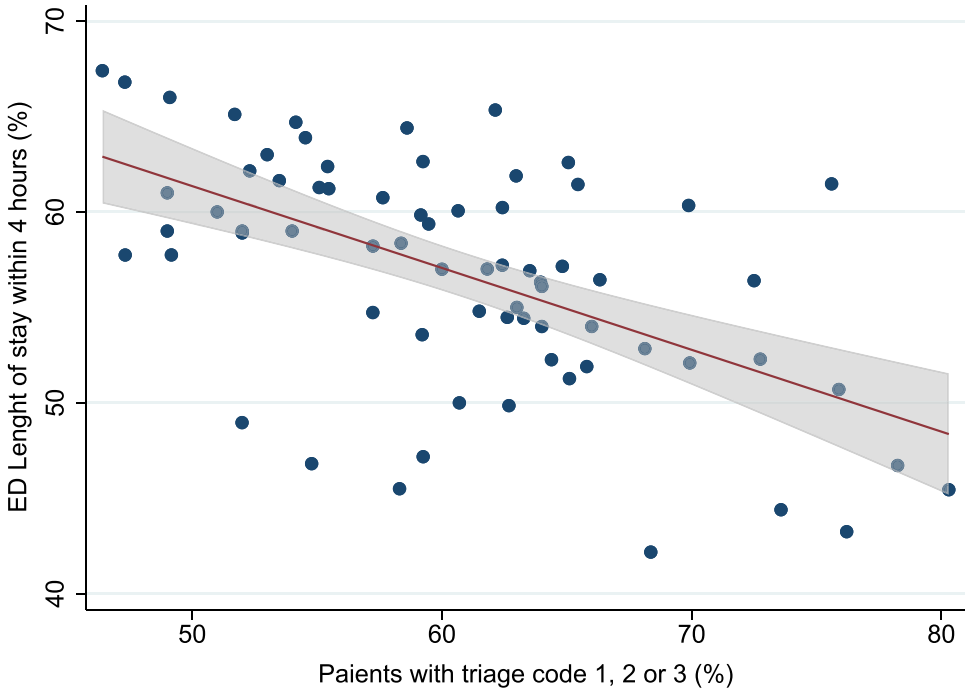

Fig. 2 Paients with triage code 1, 2 or 3 (%)

centres during the pandemic, which is much higher than the other concurrent factors.

It is obvious that the door-to-physician time depends on the presence of a physician available to visit new patients, however the number of patients an emergency physician could visit simultaneously during a shift was insufficiently reported, and our study is the first to detail this relationship also considering community hospitals of the Italian public healthcare system. Prior studies reporting measures of the physician 'productivity', defined as the number of new patients visited during a shift, have been conducted mainly in the US of America, where the emergency medicine system has profound differences compared to the Italian public healthcare system [22–27]. In addition, all these studies were conducted in academic rather than in community hospitals, severely limiting their generalizability. The hospital-level variable we focused on, presentations/physician ratio, is similar but not identical to physician productivity because it does not represent the number of patients who were initially visited by a single EP but rather, the number of patients who were discharged or admitted to the hospital by a single EP. Moreover, the length of an EP's work shift in Italy differs from other countries: two 6-h shifts during the day (from 8 to 14, and from 14 to 20) and one twelve-hour shift at night (from 20 to 8). Notwithstanding these differences, in our study the baseline values of presentations/physician ratio ranged from 11 to 19, very similar to those reported in studies performed in American [27] and in Australian [28] teaching hospitals (range 13–20). Accordingly, in our study no significant relationship were found between the door-to-physician time and the type of ED (community vs. academic hospital). This aspect strengthens the quality of our results and favours their generalizability.

With the regression analysis, we discovered a function that predicts the proportion of patients seen under 60 min starting from the number of presentations/physician ratio (Fig. 1). By way of example, when the number of presentations for each physician on duty rises over 8, the mean proportion of patients seen in less than 60 min drops below 80%. This function could be useful to establish how many physicians are needed to efficiently staff an ED if door-to-physician time is to be improved. Moreover, our function could be used to compare door-to-physician times of different hospitals, considering the number of physicians on duty and other confounding factors.

Longer patient stays in EDs are associated with higher patient mortality and worse outcomes [8]. Unlike the door-to-physician time, our data showed no significant relationship between the presentations/physician ratio and length-of-stay in the ED. Conversely, the complexity of presenting patients, expressed as the proportion of high-priority codes, was strongly related to length-of-stay and appears to explain a large part of the variability among hospitals (36%) in our analysis. We should consider this factor when comparing this performance indicator among different EDs.

Recent studies on length-of-stay have focused more often on 'output' determinants [16–19], showing a strong relationship between higher hospital-bed occupancy and longer ED length-of-stay, thus emphasizing the importance of maintaining hospital discharge levels—for example,

over weekends— to reduce having to wait at ED on subsequent days (29–31). In our study we did not investigate the relationship of ED length-of-stay with indicators of 'output' processes. Interestingly, however, our data showed that the greater the space available for each patient, the longer the ED length-of-stay, suggesting that 'space' does not always ameliorates the passage of patients through the ED, probably because of a lower 'pressure' generated by greater patient-comfort. Moreover, we found a significant relationship between the type of EDs (academic vs. community hospitals) and length-of-stay, suggesting once more that the major contributors are different from those of door-to-physician time, and that hospital-level factors should also be considered for ED lenght-of-stay.

Strength and limitations

Unlike previous studies, our study includes a large number of observations, obtained from 7 hospitals differing for census, case-mix and hospital-level factors, thereby strengthening the generalizability of our results. We also included a large, academic hospital allowing for a comparison between academic and community hospitals.

In our analysis we did not consider "output" variables such as occupancy of hospital beds, proportion of acute-care beds, or other hospital-level factors regarding departments other than the ED, such as availability and timeliness of laboratory tests, consultants, and diagnostic imaging tests. These factors, especially the time needed for the extensive use of medical protective devices and for the results of SARS-CoV-2 molecular tests, could have influenced the two performance indicators we have investigated, especially length-of-stay. Moreover, due to the lack of agreement in the first phase of the pandemia about the diagnostic codes to be used (COVID-19 was not a previously known disease) we were not able to perform a specific analysis for patients with COVID-19. This prevented us from investigating the intrinsic effect of COVID-19 on performance indicators. These aspects could be the object of future research.

Conclusions

Our data showed a strong relationship between the presentations/physicians ratio and door-to-physician time, and between the proportion of high-priority codes and ED length-of-stay, emphasising that benchmarks among different EDs should consider both hospital and patient-level factors, which are specific for each performance indicator.

Declarations

Conflict of interest The author(s) declare that they have no conflict of interest.

Human and animal rights statement All the procedures perfomed involving human participants were in accordance with the ethical standards of the istitutional research commettee and with the 1964 Helsinki declaration.

Informed consent For this type od study (retrospective extraction of anonymous data) formal consent is not required.

References

1. National Quality Forum National Voluntary Consensus Standards for Emergency Care. http://www.qualityforum.org/projects/ongoing/emergency/. (Accessed 22 June 2009).
2. Wilper AP, Woolhandler S, Lasser KE et al (2008) Waits to see an emergency department physician: US trends and predictors, 1997–2004. Health Aff (Millwood) 27:w84-95
3. Horwitz LI, Green J, Bradley EH (2010) US emergency department performance on wait time and lenght of visit. Ann Emerg Med 55:133–141
4. Paling S, Lambert J, Clouting J et al (2020) Waiting times in emergency departments: exploring the factors associated with longer patient waits for emergency care in England using routinely collected daily data. Emerg Med J 37:781–786
5. Welch SJ, Asplin BR, Stone-Griffith S, Davidson SJ, Augustine J, Schuur J (2011) Emergency department benchmarking alliance. Emergency department operational metrics, measures and definitions: results of the second performance measures and benchmarking Summit. Ann Emerg Med 58:33–40
6. Walton H, Navaratnam AV, Ormond M, Gandhi V, Mann C (2020) Emergency medicine response to the COVID-19 pandemic in England: a phenomenological study. Emerg Med J 37:768–772
7. Jeffery MM, D'Onofrio G, Paek H, Platts-Mills TF, Soares WE 3rd, Hoppe JA, Genes N, Nath B, Melnick ER (2020) Trends in emergency department visits and hospital admissions in health care systems in 5 states in the first months of the COVID-19 pandemic in the US. JAMA Intern Med 180:1328–1333
8. Mauro V, Lorenzo M, Paolo C, Sergio H (2020) Treat all COVID 19-positive patients, but do not forget those negative with chronic diseases. Intern Emerg Med 15:787–790
9. Rausei S, Ferrara F, Zurleni T, Frattini F, Chiara O, Pietrabissa A, Sarro G; for Italian Association of Hospital Surgeons, and Collected Data Contributors (2020) Dramatic decrease of surgical emergencies during COVID-19 outbreak. J Trauma Acute Care Surg 89:1085–1091
10. Harris D, Ellis DY, Gorman D, Foo N, Haustead D (2021) Impact of COVID-19 social restrictions on trau ma presentations in South Australia. Emerg Med Austr 33:152–154
11. Sun GW, Shook TL, Kay GL (1996) Inappropriate use of bivariable analysis to screen risk factors for use in multivariable analysis. J Clin Epidemiol 49:907–916
12. Health21 (1999) The health for all policy framework for the WHO European Region. (European Health for All Series; No. 6) 1. Health for all 2. Health policy 3. Health priorities 4. Regional health planning 5. Europe I.Series. ISBN 92 890 1349 4
13. NHS England. A&E attendances and emergency admissions 2018–19: monthly A&E time series. https://www.england.nhs.uk/statistics/statistical-work-areas/ae-waiting-times-and-activity/ae-attendances-and-emergency-admissions-2018–19/

14. Guttmann A, Schull MJ, Vermeulen MJ et al (2011) Association between waiting times and short term mortality and hospital admission after departure from emergency department: population based cohort study from Ontario, Canada. BMJ 342:d2983
15. Vermeulen MJ, Guttmann A, Stukel TA, Kachra A, Sivilotti ML, Rowe BH et al (2016) Are reductions in emergency department length of stay associated with improvements in quality of care? A difference-in-differences analysis. BMJ Qual Saf 25:489–498
16. Forster AJ, Stiell I, Wells G et al (2003) The effect of hospital occupancy on emergency department length of stay and patient disposition. Acad Emerg Med 10:127–133
17. Cooke MW, Wilson S, Halsall J et al (2004) Total time in English accident and emergency departments is related to bed occupancy. Emerg Med J 21:575–576
18. Boden D, Agarwal A, Hussain T et al (2015) Lowering levels of bed occupancy is associated with decreased in hospital mortality and improved performance on the 4-hour target in a UK district general hospital. BMJ 33:85–90
19. Handel D, Epstein S, Khare R, Abernethy D, Klauer K, Pilgrim R, Soremekun O, Sayan O (2011) Interventions to improve the timeliness of emergency care. Acad Emerg Med 18:1295–1302
20. Wiler JL, Gentle C, Halfpenny JM, Heins A, Mehrotra A, Mikhail MG, Fite D (2010) Optimizing emergency department front-end operations. Ann Emerg Med 55:142–160
21. Kelly SP, Shapiro N, Woodruff M et al (2007) The effects of clinical workload on teaching in the emergency department. Acad Emerg Med 14:526–531
22. France DJ, Levin S, Hemphill R et al (2005) Emergency physicians' behaviors and workload in the presence of an electronic whiteboard. Int J Med Inform 74:827–837
23. Begaz T, Decker MC, Treat R et al (2011) No relationship between measures of clinical efficiency and teaching effectiveness for emergency medicine faculty. Emerg Med J 28:37–39
24. Akbar S, Radeos MS, Yang A et al (2007) Impact of emergency medicine residents on attending physician productivity: a case-control study. Ann Emerg Med 50:S127
25. Clinkscales JD, Fesmire FM, Hennings JR et al (2016) The effect of emergency medicine residents on clinical efficiency and staffing requirements. Acad Emerg Med 23:78–82
26. Joseph JW, Davis S, Wilker EH, Wong ML, Litvak O, Traub SJ, Nathanson LA, Sanchez LD (2018) Modelling attending physician productivity in the emergency department: a multicentre study. Emerg Med J 35:317–322
27. Walker K, Ben-Meir M, Dunlop W, Rosler R, West A, O'Connor G, Chan T, Badcock D, Putland M, Hansen K, Crock C, Liew D, Taylor D, Staples M (2019) Impact of scribes on emergency medicine doctors' productivity and patient throughput: multicentre randomised trial. BMJ 364:l121
28. Paling S, Lambert J, Clouting J, González-Esquerré J, Auterson T (2020) Waiting times in emergency departments: exploring the factors associated with longer patient waits for emergency care in England using routinely collected daily data. Emerg Med J 37:781–786
29. Morley C, Unwin M, Peterson GM et al (2018) Emergency department crowding: a systematic review of causes, consequences and solutions. PLoS ONE 13:e0203316
30. Asaro PV, Lewis LM, Boxerman SB (2007) The impact of input and output factors on emergency department throughput. Acad Emerg Med 14:235–242