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Operational Determinants of Emergency Department Length of Stay: A 10-Year Big Data Analysis

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Abstract

Background

Managing patient flow in the Emergency Department (ED) is a major operational challenge involving multiple interconnected clinical and system-level processes. Emergency Department Length of Stay (LOS-ED) is a widely used operational quality metric associated with patient outcomes, physician workload, and healthcare system efficiency. We aimed to identify operational factors associated with prolonged LOS-ED and to evaluate longitudinal trends in LOS-ED over a 10-year period.

Methods

We conducted a retrospective cohort study using electronic health record data from all ED visits to a large public medical center between 2012 and 2021. Operational parameters associated with LOS-ED, including consultation burden, imaging utilization, continuity of care, patient workload, and time-based workflow metrics, were evaluated using longitudinal and multivariable analyses.

Results

Overall, 917,778 ED visits were included in the analysis. Mean LOS-ED increased during the study period from 216 to 255 minutes and exceeded four hours from 2016 onward. During the same period, the proportion of patients undergoing CT imaging increased from 3.9% to 17.5%, while the proportion requiring at least one consultation increased from 5.1% to 20.5%.

Patients requiring advanced imaging studies or multiple consultations demonstrated substantially prolonged LOS-ED. LOS-ED was significantly longer among patients undergoing ultrasonography or CT imaging compared with those who did not require advanced imaging ($p<0.001$ for both). Consultation burden demonstrated a progressive association with prolonged LOS-ED.

Random forest analysis identified consultation burden, advanced imaging utilization, continuity of care, ED workload, and time to first physician assessment as the operational variables most strongly associated with prolonged LOS-ED.

Conclusions

LOS-ED is associated with multiple interconnected operational factors extending beyond isolated time-based quality metrics. Consultation burden, imaging utilization, ED workload, and continuity of care were among the variables most strongly associated with prolonged LOS-ED. Improving ED performance may therefore require broader systems-based approaches targeting operational bottlenecks and workflow processes.

INTRODUCTION

The Emergency Department (ED) is a major component of hospital activity worldwide and serves as the primary entry point for more than 50% of hospitalized patients (1). Patients may present to the ED regardless of disease severity due to limited access to primary care services or socioeconomic barriers affecting healthcare utilization (2, 3, 4). The ED provides rapid access to clinical evaluation, specialist consultations, laboratory testing, and advanced imaging compared with ambulatory or community healthcare settings. Multiple factors have been associated with Emergency Department Length of Stay (LOS-ED), including system-related, patient-related, and healthcare provider-related factors (5, 6, 7). LOS-ED may increase according to the complexity and extent of the clinical assessment required (8, 9).

Reducing LOS-ED is considered an important operational objective that may improve patient flow, hospital efficiency, physician workload, and patient satisfaction (10). Beginning in 2016, the Israeli Ministry of Health implemented a national incentive program designed to reduce LOS-ED by monitoring predefined operational milestones, including time to triage, time to first physician examination, time to clinical decision-making, and waiting time for discharge or hospital admission. Each parameter was scored, and financial incentives were allocated according to overall institutional performance. However, the association between these operational metrics and overall LOS-ED remains unclear.

Despite widespread implementation of time-target policies, limited evidence exists regarding which operational factors are most strongly associated with prolonged LOS-ED in real-world large-scale healthcare systems.

STUDY AIM

The primary objective of this study was to identify operational factors associated with prolonged Emergency Department Length of Stay (LOS-ED). In addition, we evaluated longitudinal trends in LOS-ED throughout the study period.

MATERIALS AND METHODS

This study was approved by the institutional research ethics committee (protocol 107-22-ASF). Data extraction and analysis were performed between January 2023 and April 2024. Shamir Medical Center is a 900-bed public university-affiliated medical center.

We retrospectively reviewed the records of all patients who visited the ED at Shamir Medical Center between January 1, 2012 and December 31, 2021.Pediatric patients (< 18 years of age) and patients directly referred to obstetrics and gynecology, ophthalmology, or otolaryngology services were excluded. Patients treated under dedicated COVID-19 protocols during the pandemic period were excluded because they were managed through separate operational pathways.

Parameters

The database included demographic variables (age and sex), arrival characteristics, working shifts (morning 08:00–16:00, evening 16:00–23:00, and night 23:00–08:00), mode of arrival (self-arrival or ambulance transport), triage acuity level according to the Canadian Emergency Department Triage and Acuity Scale (CTAS) Guidelines 2016 (11), and LOS-ED. LOS-ED was defined as the total time from patient registration in the ED until discharge or hospital admission.

Because the study aimed to evaluate operational determinants of LOS-ED within the context of the Israeli national incentive program, two operational parameters included in the national incentive program were specifically evaluated: time to triage and time to first physician examination. Time to triage was defined as the interval between ED registration and the initial nursing assessment and was categorized into three groups: <15 minutes, 15–60 minutes, and > 60 minutes. Time to first physician examination was defined as the interval between ED registration and the initial physician assessment and was categorized into three groups: <1 hour, 1–2 hours, and > 2 hours.

Additional operational workflow variables were evaluated to assess ED processes potentially associated with prolonged LOS-ED. ED workload (“patient load”) was defined as the number of patients physically present in the ED at the time of patient arrival. Continuity of care was evaluated according to whether the same physician managed the patient from the initial evaluation through the final disposition decision.

We further evaluated operational processes related to diagnostic testing and specialist consultations including, advanced imaging studies, including computed tomography (CT) and ultrasonography (US), together with imaging turnaround times. Imaging turnaround time was defined as the interval between imaging request documentation and the final radiology report. Consultation turnaround time was defined as the interval between consultation request documentation and completion of the consultant’s evaluation. The total number of consultations per patient was evaluated as a separate operational parameter.

Because consultation and imaging processes may occur simultaneously, overlapping operational delays were considered during analysis. To minimize overlap between parallel operational processes, the association of consultation and imaging requirements with LOS-ED was evaluated by comparing patients who required these services with those who did not.

Operational parameters were evaluated longitudinally throughout the study period to identify trends associated with LOS-ED. Analyses were performed separately for admitted and discharged patients, and the association between each operational parameter and LOS-ED was evaluated by comparing mean LOS-ED values across study variables.

Statistical analysis

Descriptive statistics are presented as mean and standard deviation (SD) for continuous variables and as counts with percentages for categorical variables, stratified according to patient disposition. Comparisons between study groups were performed using Student’s t-tests and analysis of variance (ANOVA) for continuous variables. To evaluate associations between operational parameters and LOS-ED, Spearman correlation analysis was performed for continuous operational variables. Additional interaction analyses were conducted according to patient disposition and operational variables, including triage acuity and time to first physician examination, in order to further characterize their association with LOS-ED.

Temporal and longitudinal trends in LOS-ED were evaluated according to admission status and time-related operational variables, including year, month, day of the week, and working shift. Longitudinal changes in LOS-ED and operational parameters throughout the study period were assessed using descriptive statistical methods. Because LOS-ED demonstrated a non-normal distribution, log-transformed LOS-ED values were used for multivariable analyses. To identify operational variables most strongly associated with LOS-ED, an exploratory random forest model using log-transformed LOS-ED values was performed separately for admitted and discharged patients.

Variable importance was estimated using permutation importance analysis, in which variable importance was determined according to the decrease in model performance following random permutation of the analyzed variable. Variable importance was defined as the difference between baseline model performance and model performance following permutation of the analyzed variable (Fig. 1).

A two-sided p-value < 0.05 was considered statistically significant.

RESULTS

During the study period, more than 1.5 million patient visits were recorded in the ED of Shamir Medical Center, of which 917,778 met the study inclusion criteria. The mean annual number of ED visits was 91,778, ranging from 77,587 in 2020 to 99,731 in 2015, without a consistent temporal trend. However, several patients- and system -related characteristics changed substantially throughout the study period. Mean patient age increased progressively during the study period, from 45.6 years in 2012 to 51.0 years in 2021 while no major temporal changes were observed in patient arrival patterns across working shifts. In parallel, several operational processes demonstrated substantial longitudinal changes over time. The proportion of patients undergoing CT imaging increased from 3.9% to 17.5%, while the proportion requiring at least one consultation increased from 5.1% to 17.4% throughout the study period. Correspondingly, mean LOS-ED increased from 214 minutes in 2013 to 259 minutes during 2019–2020, exceeding four hours from 2016 onward. (Table 1)

Table 1
Longitudinal changes in operational parameters during the study period.

Number of records		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
		85436	90081	93073	99731	99721	98105	94275	92193	77587	87576	917778
Average time (minutes)	Mean (SD)	216.2 (148.5)	214.7 (137.7)	223.9 (146.3)	236.6 (156.7)	244.7 (159.4)	253.7 (140.2)	248.4 (152.9)	259.5 (161.8)	259.6 (162.9)	255.8 (160.2)	241.3 (148.3)
age	Mean (SD)	45.6 (23.3)	46.3 (23.4)	47.0 (23.7)	47.7 (23.8)	48.4 (23.6)	49.4 (23.6)	50.5 (23.4)	51.0 (23.4)	51.0 (23.2)	50.5 (23.2)	48.7 (23.6)
Arrived by Ambulance		12293 (14.4)	14183 (15.7)	14984 (16.1)	17779 (17.8)	19231 (19.3)	20822 (21.2)	26166 (27.8)	28858 (31.3)	25863 (33.3)	27531 (31.4)	207710 (22.6)
Shift	8–16	38336 (44.9)	40669 (45.1)	42644 (45.8)	45854 (46.0)	46147 (46.3)	44556 (45.4)	42739 (45.3)	41524 (45.0)	34890 (45.0)	39159 (44.7)	416518 (45.4)
	16–23	32815 (38.4)	34277 (38.1)	35344 (38.0)	37253 (37.4)	37025 (37.1)	36548 (37.3)	34627 (36.7)	33983 (36.9)	28567 (36.8)	32527 (37.1)	342966 (37.4)
	23 – 8	14285 (16.7)	15135 (16.8)	15085 (16.2)	16624 (16.7)	16549 (16.6)	17001 (17.3)	16909 (17.9)	16686 (18.1)	14130 (18.2)	15890 (18.1)	158294 (17.2)
Triage waiting time groups	15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	57084 (67.7)	59715 (70.8)	43712 (64.5)	55889 (73.4)	219331 (69.2)
	15–60	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	25743 (30.6)	23790 (28.2)	22637 (33.4)	19188 (25.2)	92598 (29.2)
	> 60	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1433 (1.7)	873 (1.0)	1409 (2.1)	1073 (1.4)	4832 (1.5)
Triage level	1	-	-	-	-	-	-	2346 (2.5)	666 (0.7)	631 (0.8)	652 (0.7)	4712 (0.5)
	2	-	-	-	-	-	-	13681 (14.5)	7929 (8.6)	6628 (8.5)	7131 (8.1)	37846 (4.1)
	3	-	-	-	-	-	-	38197 (40.5)	45075 (48.9)	34472 (44.4)	46043 (52.6)	165073 (18.0)
	4	-	-	-	-	-	-	23827 (25.3)	25809 (28.0)	21016 (27.1)	20037 (22.9)	90691 (9.9)
	5	-	-	-	-	-	-	8320 (8.8)	6892 (7.5)	6797 (8.8)	5624 (6.4)	27633 (3.0)
Laboratory		47656 (55.8)	51500 (57.2)	54788 (58.9)	61133 (61.3)	62006 (62.2)	62554 (63.8)	61423 (65.2)	61098 (66.3)	52636 (67.8)	58892 (67.2)	573686 (62.5)
Admission		10143 (11.9)	13864 (15.4)	17815 (19.1)	22539 (22.6)	22012 (22.1)	22824 (23.3)	23236 (24.6)	22210 (24.1)	20027 (25.8)	21275 (24.3)	195945 (21.3)
Time to first physician examination	< 1 hour	13765 (51.8)	13432 (49.7)	16071 (37.4)	16952 (27.6)	15409 (25.1)	18123 (26.2)	29834 (38.3)	40769 (47.3)	40530 (53.4)	44828 (52.8)	249713 (40.7)
	1–2 hours	6500 (24.4)	7208 (26.7)	9322 (21.7)	11369 (18.5)	11279 (18.3)	14791 (21.4)	20728 (26.6)	28037 (32.5)	26773 (35.3)	30182 (35.5)	166189 (27.1)
	> 2 hours	6332 (23.8)	6397 (23.7)	17620 (41.0)	33033 (53.8)	34779 (56.6)	36131 (52.3)	27245 (35.0)	17392 (20.2)	8579 (11.3)	9927 (11.7)	197435 (32.2)
US		3210 (3.8)	3546 (3.9)	3829 (4.1)	4411 (4.4)	4798 (4.8)	4767 (4.9)	4632 (4.9)	3870 (4.2)	2270 (2.9)	2501 (2.9)	37834 (4.1)
US time	Mean (SD)	89.5 (144.0)	112.5 (207.3)	122.8 (197.9)	119.7 (102.9)	135.3 (1043.5)	125.1 (132.8)	122.6 (136.4)	138.4 (295.3)	147.1 (118.0)	135.0 (130.7)	124.4 (405.7)
CT		3331 (3.9)	4907 (5.4)	6283 (6.8)	8201 (8.2)	9700 (9.7)	11392 (11.6)	12210 (13.0)	13334 (14.5)	12701 (16.4)	15312 (17.5)	97371 (10.6)
CT_time	Mean (SD)	103.3 (159.5)	126.4 (162.6)	139.1 (381.3)	137.1 (383.2)	136.9 (127.1)	141.1 (169.2)	127.9 (351.6)	138.9 (437.6)	156.4 (680.8)	202.7 (3757.1)	147.9 (1533.4)
Number of consultations	0	81057 (94.9)	83262 (92.4)	83220 (89.4)	86980 (87.2)	83106 (83.3)	79614 (81.2)	74853 (79.4)	73288 (79.5)	62525 (80.6)	69589 (79.5)	777494 (84.7)
	1	4325 (5.1)	6219 (6.9)	8536 (9.2)	11001 (11.0)	14168 (14.2)	15688 (16.0)	16473 (17.5)	16006 (17.4)	12744 (16.4)	15257 (17.4)	120417 (13.1)

Number of records	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
	85436	**90081**	**93073**	**99731**	**99721**	**98105**	**94275**	**92193**	**77587**	**87576**	**917778**
2	53 (0.1)	552 (0.6)	1193 (1.3)	1583 (1.6)	2181 (2.2)	2451 (2.5)	2583 (2.7)	2526 (2.7)	1981 (2.6)	2351 (2.7)	17454 (1.9)
3+	1 (0.0)	48 (0.1)	124 (0.1)	167 (0.2)	266 (0.2)	352 (0.3)	366 (0.3)	373 (0.4)	337 (0.4)	379 (0.3)	2413 (0.2)

Imaging and LOS-ED

Advanced imaging utilization was significantly associated with prolonged LOS-ED. Patients requiring ultrasonography (US) demonstrated significantly longer LOS-ED compared with patients who did not require US (370 vs. 236 minutes, $p < 0.001$). Similarly, patients requiring CT imaging demonstrated prolonged LOS-ED compared with patients who did not require CT imaging (370 vs. 226 minutes; discharge group $r = 0.52$, admission group $r = 0.45$, $p < 0.001$). Longer imaging turnaround times were also associated with prolonged LOS-ED. (Table 2)

Table 2
– Association between operational parameters and ED length of stay

		Time Mean (SD)	Time interval (minutes)	P value
Arrived by Ambulance	Yes	288.4 (973.1)	61	< 0.001[a]
	No	227.5 (147.1)		
Shifts	8–16	242.8 (151.7)	7	< 0.001[b]
	16–23	235.8 (760.6)	-	
	23 – 8	249.0 (170.4)	14	
Time to triage (minutes)	15	254.8 (160.2)	-	< 0.001[b]
	15–60	264.6 (153.3)	10	
	> 60	326.8 (177.9)	72	
Laboratory exam	Yes	289.4 (596.4)	128	< 0.001[a]
	No	161.0 (121.1)		
Time to first physician examination	Up to 1 hour	189.6 (146.2)	-	< 0.001[b]
	1–2 hours	234.0 (146.0)	45	
	More than 2 hours	306.3 (143.7)	117	
Continuity of care by the same physician	Yes	206.8 (137.4)	87	< 0.001[a]
	No	293.3 (160.6)		
US	Yes	370.4 (2250.3)	135	< 0.001[a]
	No	235.7 (152.2)		
CT	Yes	370.4 (187.7)	145	< 0.001[a]
	No	225.9 (502.8)		
Number of consultations	0	223.8 (516.0)	-	< 0.001[b]
	1	325.6 (164.5)	102	
	2	405.3 (183.5)	182	
	3	473.5 (205.9)	250	
	4	493.8 (205.8)	270	
	5	469.4 (211.1)	246	
	6	510.2 (423.6)	287	
Triage level	1	242.2 (163.7)	50	< 0.001[b]
	2	279.5 (161.9)	87	
	3	284.5 (161.3)	92	
	4	224.5 (146.0)	31	
	5	192.3 (137.6)	-	
a – T test. b – One way ANOVA with Bonferroni correction				
US – Ultrasound, CT – Computer Tomography.				

Consultations and LOS-ED

Consultation-related operational processes demonstrated similar associations with LOS-ED. Patients who did not require consultations had a mean LOS-ED of 224 minutes, whereas LOS-ED progressively increased among patients requiring one to six consultations (325, 405, 473, 494, 469, and 510 minutes, respectively; discharge group $r = 0.44$, admission group $r = 0.32$, $p < 0.001$). (Table 2). Only weak correlations were observed between triage acuity and both diagnostic testing volume and consultation burden ($r = 0.090$ and $r = 0.098$, respectively; $p < 0.001$ for both).

Random forest analysis

To further characterize the operational variables most strongly associated with LOS-ED, random forest analysis identified the operational variables most strongly associated with LOS-ED: (1) number of consultations, (2) advanced imaging utilization (CT or US), (3) continuity of care by the same physician throughout the ED stay, (4) ED workload ("patient load"), and (5) time to first physician examination. Figure 1 demonstrates the relative importance of these parameters separately for admitted (A) and discharged (B) patients. Among discharged patients, laboratory turnaround time was also significantly associated with prolonged LOS-ED.

DISCUSSION

LOS-ED represents a major operational challenge worldwide and is influenced by multiple clinical and organizational factors. Prolonged LOS-ED reflects a complex interaction between processes occurring both within and outside the ED (5). Previous studies evaluating the association between LOS-ED and in-hospital mortality have demonstrated inconsistent findings (12, 13). However, prolonged LOS-ED has consistently been associated with reduced patient satisfaction (14, 15).

Time-target programs

One commonly adopted strategy for reducing LOS-ED is the implementation of predefined time-based targets, in which hospitals are evaluated according to the proportion of patients discharged or admitted within specified timeframes. Several studies have evaluated the association between time-based targets and patient outcomes. Jones et al. demonstrated improved operational outcomes following implementation of time-based targets, although these improvements were accompanied by increased readmission rates (16, 17). Forero et al. evaluated the impact of four-hour target programs on mortality, overcrowding, and patient flow and demonstrated limited effects on mortality outcomes (18). The Israeli Ministry of Health implemented a national incentive program based on predefined LOS targets and operational milestones, including time to triage and time to first physician examination.

Our findings suggest that total LOS-ED alone may not represent a sufficient measure of ED operational performance. Similarly, isolated measurement of time-based milestones, such as time to triage or time to first physician assessment, may incompletely reflect the complexity of patient flow processes occurring throughout the ED stay. A more comprehensive evaluation of operational factors contributing to prolonged LOS-ED may support development of targeted process-based quality metrics and operational interventions aimed at improving ED efficiency and patient flow.

First physician assessment

Time to first physician assessment was significantly associated with overall LOS-ED. Notably, this parameter is included among the operational metrics evaluated within the national incentive program. This association was observed across multiple triage levels and regardless of final patient disposition, suggesting that time to initial physician assessment may represent a relevant operational metric for evaluation of ED patient flow processes. At the same time, this metric is also influenced by additional operational processes, including triage efficiency and pre-physician laboratory workflows.

Laboratory testing

Previous studies suggested that initiating laboratory testing prior to physician assessment does not necessarily reduce overall LOS-ED, except in selected clinical scenarios such as acute chest pain. Nevertheless, dedicated phlebotomy workflows and streamlined laboratory processes may still provide operational advantages in selected patient populations (19).

In our cohort, laboratory turnaround time was significantly associated with LOS-ED among discharged patients, whereas this association was less prominent among admitted patients. This difference may reflect the greater influence of downstream operational and hospitalization-related constraints among admitted patients, in whom factors beyond diagnostic workflow may substantially contribute to prolonged LOS-ED.

ED workload

ED workload ("patient load") was significantly associated with prolonged LOS-ED. Higher patient load likely reflects increased operational pressure on clinical teams and reduced system efficiency, potentially impairing workflow efficiency, delaying clinical decision-making, and reducing operational throughput within the ED. Although the factors leading patients to seek ED care extend beyond the scope of the current study, these findings highlight patient load as an important operational parameter associated with ED efficiency and patient flow. Given that patient volume itself may not always be directly modifiable at the institutional level, the findings emphasize the importance of identifying operational processes that can be optimized under conditions of increased workload in order to improve ED performance and reduce LOS-ED.

Continuity of care

Continuity of care by the same physician throughout the ED stay was associated with shorter LOS-ED and may represent an important component of ED workflow efficiency. Continuity of care may additionally influence time to first physician assessment, clinical decision-making, and patient

disposition processes. Operationally, ED physicians are frequently required to balance between completing the management and disposition of patients already undergoing treatment and evaluating newly arrived patients which may fragment continuity of care and impair workflow efficiency. These findings highlight the potential operational importance of maintaining continuity of care and supporting completion of ongoing patient management processes in order to reduce LOS-ED, particularly under conditions of increased workload.

Imaging and consultations

Patients requiring imaging studies and multiple consultations demonstrated substantially prolonged LOS-ED, particularly when several consultations accumulated during the ED stay. These findings suggest that consultation workflows, imaging availability, and interdepartmental coordination represent major operational bottlenecks associated with prolonged LOS-ED.

Because many of these processes depend on services outside the ED itself, improvement strategies would likely require broader institutional collaboration, including coordination with radiology departments and consulting services. At the same time, the presence of these operational bottlenecks may support development of streamlined care pathways for selected patients who are less likely to require advanced imaging studies or specialist consultations. Facilitating more rapid evaluation and disposition of such patients may shorten LOS-ED while additionally reducing operational overload within the ED.

Accordingly, targeting these operational bottlenecks may represent an important systems-based approach for improving patient flow and reducing LOS-ED.

Aging and patient complexity

Patient-related characteristics may also contribute to prolonged LOS-ED. In our cohort, mean patient age increased by approximately five years during the study period. As life expectancy increases, ED populations are becoming older and medically more complex, often requiring more comprehensive clinical assessment, diagnostic evaluation, and management (20).

Although the annual number of ED visits remained relatively stable, increasing patient complexity may nevertheless have contributed to greater operational burden and prolonged LOS-ED (21). These findings further emphasize the importance of adaptive operational models capable of addressing increasing patient complexity while maintaining efficient patient flow and resource allocation within the ED.

LIMITATIONS

This study has several important limitations. First, this was a single-center retrospective study, and therefore the findings may not be generalizable to other healthcare systems or institutional settings. In addition, the observational design does not allow establishment of causal relationships between operational variables and prolonged LOS-ED.

Consultation availability and workflow processes may additionally be influenced by institutional policies, staffing limitations, budgetary constraints, and local operational practices rather than solely by clinical necessity. Furthermore, the study did not include several potentially relevant clinical variables, including comorbidity burden and disease-specific severity measures, which may also influence LOS-ED and operational complexity.

Nevertheless, the large cohort size and extended study period may partially mitigate the effect of local operational variability and provide meaningful insight into operational processes associated with prolonged LOS-ED.

CONCLUSIONS

LOS-ED is associated with multiple interrelated operational and patient-related factors that extend beyond isolated time-based quality metrics. Consultation burden, imaging utilization, ED workload, and continuity of care were among the operational variables most strongly associated with prolonged LOS-ED. These findings suggest that improving ED performance may require broader systems-based approaches targeting operational bottlenecks, workflow processes, and interdepartmental coordination rather than reliance on isolated time-target metrics alone. Further studies are needed to evaluate whether such operational and systems-based interventions may improve patient flow and potentially reduce LOS-ED.

Declarations

Author contributions:

Conceptualization: YH, JH, OT.

Methodology: YH, JH, OT.

Formal analysis and investigation: MB.

Writing - original draft preparation: YH, OT, IJ.

Writing - review and editing: YH, JH ,OT.

Ethics approval and consent to participate: This study was approved by the Shamir Medical Center ethics committee (protocol 107-22-ASF). All methods were performed in accordance with the ethical standards as laid down in the Declaration of Helsinki and its later amendments or comparable ethical standards. The need for informed consent was waived since no individual person's data was taken.

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Figures

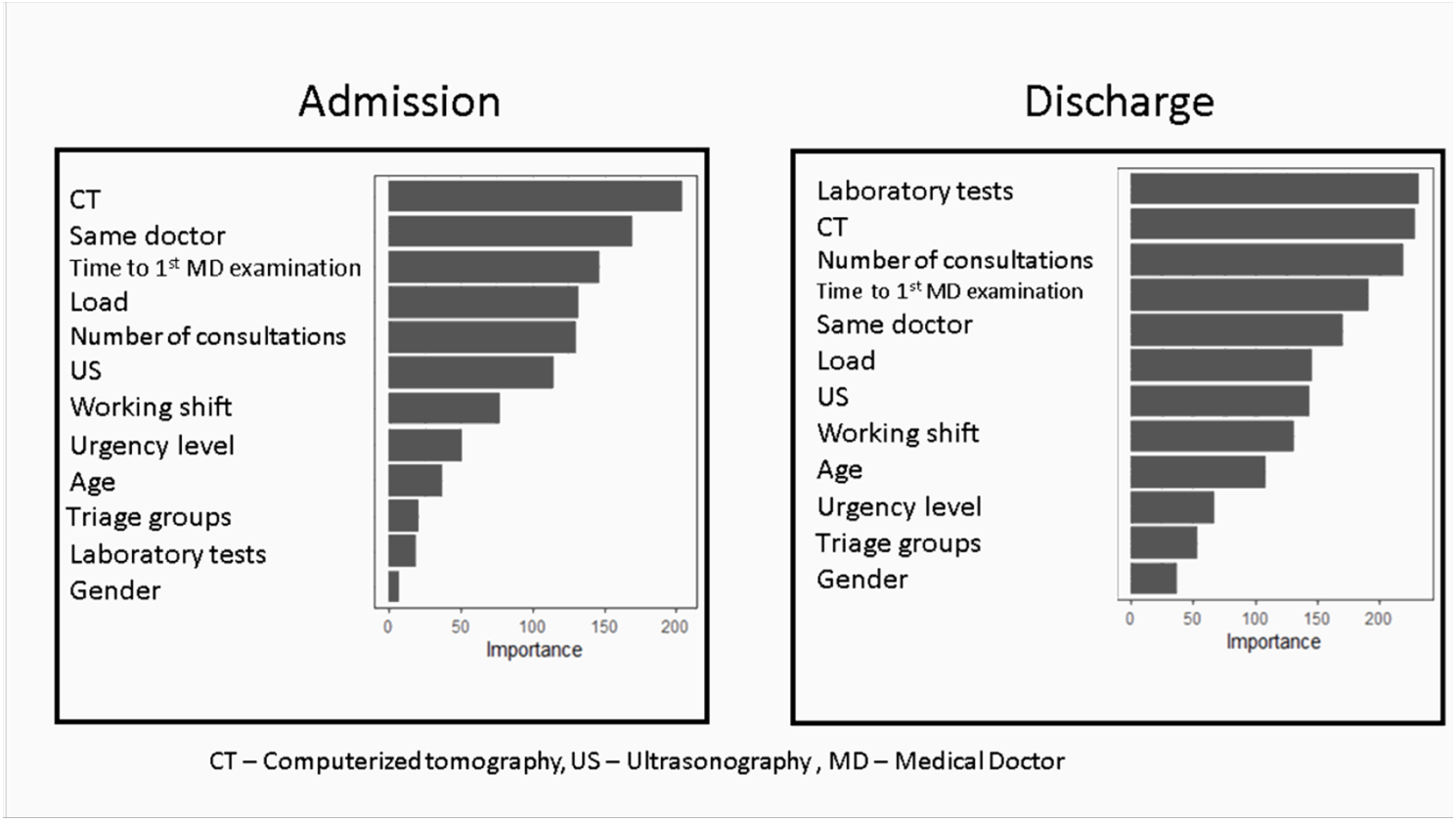


Figure 1

Variable importance analysis of operational parameters associated with LOS-ED.

Random forest permutation importance analysis demonstrating the relative contribution of operational variables to LOS-ED among admitted (A) and discharged (B) patients.