ORIGINAL ARTICLE
EMERGENCY MEDICINE FELLOWSHIP: LENGTH-OF-STAY IMPACT OF ESTABLISHING A LARGE POST-RESIDENCY TRAINING PROGRAM

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Background: The length of stay (LOS) is an important operational parameter closely followed in emergency department (ED). This study aims to assess operations impacts of a large post-residency EM Fellowship (EMF) program on LOS. **Methods:** This was a retrospective database analysis of data collected automatically by the study ED's electronic medical record (EMR) for one full academic year, starting in September 2016. The main dependent variable was LOS for the cases discharged after EM-only evaluation (LOS_{DCEM}), and the independent variable of interest was the proportion of EMFs as a % of all on-duty ED physicians during the shift the patient presented. **Results:** During the study period, the ED census for patients discharged after EM-only evaluation was 327,527. Exclusion of 5,803 EMR-downtime cases (1.8% of 327,527) and 845 (0.3% of 327,527) cases with LOS exceeding 24 hours, the final study set comprised 320,879 LOS_{DCEM} cases. The EMF proportion of on-duty ED physicians, was statistically significant at the lowest three τ levels but not significant at the higher six τ levels. For the 10th, 20th, and 30th percentiles of LOS_{DCEM}, the % relative improvements in LOS_{DCEM} achieved by increasing the EMF proportion 1% were, respectively, 13% (6.5/52), 8% (6.8/83), and 7% (8.1/115). **Conclusion:** The LOS_{DCEM} does not appear to be unfavourably impacted by increasing the proportion of EMFs as a % of all on-duty ED physicians. The EMFs numbers (as a percentage of all on-duty physicians) disproportionately improves LOS_{DCEM} for those patients with shorter LOS.
Keywords: Emergency department; Operation parameters: Length-of-stay; Trainees; EM fellowship; Emergency Medicine Fellowship

INTRODUCTION

Time intervals are among the most closely followed Emergency Department (ED) operational parameters. Of the many such intervals that are important, one that is relatively more under the control of the Emergency Medicine (EM) physician is the length of stay (LOS) in the ED for cases that are discharged after being evaluated only by the EM service.[1] These cases, evaluated and released from the ED by EM in the absence of consultation to another clinical service, are denoted herein as DC_{EM}.

Utilization of more-experienced EM physicians during early evaluation of ED cases (*e.g.* by placing senior physicians at triage) has been demonstrated to improve efficiency and decrease LOS.[2] The EM evidence base contains less information on the question of whether a large post-residency training program affects LOS.

As a result of the structure of EM training programs in regions from which most ED operations literature is generated (*i.e.* in the USA and Europe), there are few if any studies that assess operations impacts of a large post-residency EM Fellowship (EMF).[3] From its 2014 commencement with a dozen participants, the EMF program has matured to include

triple that number and the fellows account for a substantial portion of the EM physician group.

The investigators' overarching aim was to shed light on the ED operations impact of a large EMF program at the busy ED of Hamad General Hospital (HGH) in Qatar. When considering viable LOS endpoints, the investigators wished to focus on an outcome less subject to confounding by non-EMF factors such as consulting-service response times or lack of inpatient beds. Therefore, the study's specific operations endpoint of focus was LOS in DC_{EM} cases (henceforth denoted LOS_{DCEM}).

Introduction of a significant EMF presence could conceivably move LOS_{DCEM} in either direction. Disposition could be expedited due to EMFs' ability to autonomously discharge patients. On the other hand, disposition time could be slowed by the requirement for EMFs (as relatively junior physicians in a training program) to discuss challenging cases with on-site EM Consultants. It is possible that the effect of the EMF program on LOS_{DCEM} could vary with factors such as patient complexity.

At the study ED, EM physicians other than Consultants fall into one of three grades: residents, fellows, and Specialists (board-certified physicians who have completed residency only). The grades' varying

non-clinical calendars (*e.g.* for grade-specific education sessions) create shift-to-shift variance in specific-grade proportions of on-duty physicians. This study's specific aim was to assess, while adjusting for confounders such as patient census, acuity, and overall physician numbers, whether change in EMF proportion of on-duty physicians was associated with changes in LOS_{DCEM}. The study further aimed to determine whether any effects of EMF proportions on LOS_{DCEM} that may exist, were similar across the range of LOS_{DCEM} observed in the study group.

MATERIAL AND METHODS

This was a retrospective database analysis of data collected automatically by the study ED's electronic medical record (EMR). The EMR (Cerner Millennium, Kansas City, Missouri USA) includes standard demographic information as well as operations times of interest (*e.g.* registration time, initial physician evaluation time, and discharge time). The EMR also indicates ultimate disposition, and whether patients had consults to non-EM clinical services. The EMR's protocols for recording and reporting data did not change during the study period.

Patients were assessed for one full academic year, starting in September 2016. Study cases were those ED patients discharged after evaluation by EM only (no consultation, no admission). Because of known issues with EMR accuracy, an *a priori* decision was made to exclude cases with LOS_{DCEM} exceeding 24 hours; at the study centre these cases are nearly always incorrectly coded (e.g., admitted rather than discharged) by the EMR. In this administrative study, there was no analysis of patient identifiers or protected health information.

The study was conducted over the study center's academic year, which for EMFs commences in autumn. Cases were accrued for 52 weeks commencing with the mid-September 2016 graduation of the centre's first EMF class. The study's mid-month start and finish meant that the study period included 13 calendar months or partial months.

Hamad General Hospital is the only tertiary-care general hospital within Qatar's government-operated healthcare system. As the sole high-level ED for a country with population exceeding 2.6 million, HGH's emergency centre is busy: during the study year the overall ED census was nearly 480,000. This study's LOS_{DCEM} endpoint was calculated for the 320,879 cases (67% of overall census) that were discharged after EM-only evaluation.

The ED uses tiered physician staffing. Overall supervision comes from 40 EM Consultants, while most direct care is provided by approximately 100 Specialist-grade EM physicians (i.e., post-residency, EM-boarded physicians akin to clinical faculty in the USA). There

are also approximately 40 EMFs (similar to PGY5 through PGY7 in the USA). The centre's 48 residents are in a four-year program accredited (since 2016) by the international branch of the Accreditation Council of Graduate Medical Education (ACGME-I).

The ED operates in three shifts of 8-hour duration: day (0600–1400), evening (1400–2200), and night (2200–0600). During the study time frame there was little variation in the numbers of on-duty Consultants in the day (four Consultants), evening (six Consultants), and night shifts (three Consultants). Coverage by the other grades of EM physicians varied by shift and weekday. For example, since more junior trainees' academic days occur on Tuesdays all residents and non-senior EMFs are non-clinical Monday night through Tuesday afternoon.

The ED's goal is to have the same overall number of physicians – a combination of all grades – on duty each day. The goals for non-Consultant physician *n* for the day, evening, and night shift differ depending on the shift's mix of Specialists and trainees but based on previous work (using predictive marginal probability analysis) the study center aims to staff the ED with 20-24 physicians for day and evening shifts and 16-20 for the night shift.[3]

The ED is divided into separate areas that see different patient populations, but all EM physicians are eligible to cover all areas of the ED. As general EM physicians, the ED physicians see adult and paediatric patients. Although the ED sees over 45,000 paediatric cases annually, there is no specially demarcated "paediatric area." The EMR reporting capability during the study period did not reliably include delineation of LOS_{DCEM} by ED area. After excluding the 30 beds comprising the ED's critical-care areas, the number of beds giving rise to LOS_{DCEM} cases was approximately 100 (the number of ED beds fluctuated during the study period due to construction).

During the study period the ED transitioned from a hospital-specific triage acuity system to the five-level Canadian Triage Acuity Score (CTAS), which is often used in hospitals in the Middle East (where the study was executed).[4] The transition from one triage system to another introduced variation in triage scoring. In order to allow for triage acuity adjustment over a study period that included a many-months era of CTAS transition, an *a priori* decision was made to stratify cases into "higher acuity" (top two CTAS tiers), intermediate acuity (CTAS of 3), and lower acuity (CTAS of 4 or 5).

Descriptive analysis of continuous variables such as LOS_{DCEM} (which were not normal as assessed with Shapiro-Wilk testing) used median and interquartile range (IQR), as per the preferred approach for time-to-event data.[5] The study plan called for assessing associations between the dependent variable

LOS_{DCEM} and the main independent variable of interest, the proportion of EMFs as a % of all on-duty ED physicians during the shift the patient presented. Potential confounders were selected for inclusion in modelling based on previous work at the study center.[2,3] Covariates included patient factors (sex, age group, ED arrival mode, and triage acuity) as well as factors characterizing operational status of the ED for the shift during which patients presented. Shift-based operations covariates included *n* of all-grade on-duty ED physicians and well as numbers of patients, ambulance arrivals, and ED boarders (admissions still in the ED awaiting an inpatient bed). Other covariates included the shift (day, evening, or night) during which patients presented, whether the visit occurred on a Friday (the country's holy day), and study week (1 through 52).

RESULTS

During the study period, the ED census for patients discharged after EM-only evaluation was 327,527. Exclusion of 5,803 EMR-downtime cases (1.8% of 327,527) and 845 (0.3% of 327,527) cases with LOS exceeding 24 hours, the final study set comprised 320,879 LOS_{DCEM} cases.

Table-1 shows patient characteristics and ED characteristics for the shift during which patients presented. The patients were representative of the study center's ED population (and the population of the country at large) in their male predominance and relatively young age. For physician numbers on-duty when patients presented, only physicians with clinical autonomy were counted (medical students and junior EM residents were not counted). The number of EMFs on duty ranged from zero to 19 and Table-1 shows information on EMF proportions of overall physician n.

The central tendency and dispersion of LOS_{DCEM} are shown in table-2. Table-2 includes deciles of LOS_{DCEM} with their exact 95% CIs. These deciles defined the τ values subsequently used for quantile regression. Figure-1 is a quantile plot of LOS_{DCEM} demonstrating that, even after previously noted exclusion of cases with LOS exceeding 24 hours, the LOS_{DCEM} data have a non-normal distribution.

Models were generated for each of the nine τ levels corresponding to deciles of LOS_{DCEM}. The primary independent variable of interest, EMF proportion of on-duty ED physicians, was statistically significant at the lowest three τ levels but not significant at the higher six τ levels (Table-3). Statistical significance of the EMF proportion as a predictor was confirmed with bootstrapped (100-repetition) CIs.

For the quantile regression models at each τ level, interpretation of the β coefficient (and its 95% CI) is the same as for standard linear regression models. For instance, at the τ 10 level (i.e. fastest LOS_{DCEM} decile)

each incremental rise of 1% of EMFs as a proportion of all on-duty physicians speeds up LOS_{DCEM} by 6.5 minutes. At the next decile (τ 20), a similar rise of 1% of EMF proportion improved (*i.e.* decreased) LOS_{DCEM} by 7.8 minutes.

The table-3 results can be interpreted in light of the table-2 information on the actual LOS_{DCEM} quantiles. For the 10th, 20th, and 30th percentiles of LOS_{DCEM}, the % relative improvements in LOS_{DCEM} achieved by increasing the EMF proportion 1% were, respectively, 13% (6.5/52), 8% (6.8/83), and 7% (8.1/115).

The full models for each of the nine quantile regressions (one per decile) are reported in the Appendix. The Appendix includes the final models for each quantile, which incorporate the covariates that were statistically significant at that level. As previously noted, the CIs reported were calculated using bootstrapping as well as a simultaneous quantile registration procedure that accounts for the fact that CIs for each regression model may not be fully independent (since they are bootstrapped from the same overall data set).

Table-1: Descriptive statistics for cases seen and discharged by the Emergency Medicine (EM) service

Patient factors	
Overall study group: Patients seen and discharged by EM	320,879 (100%)
Male	221,862 (69.1%)
Age	
Overall median and interquartile range (IQR)	31.6 (14.9-51.8)
Geriatric (65+ years)	10,185 (3.2%)
Adult (18-64 years)	276,150 (86.1%)
Pediatric (up to 18 years)	34,544 (10.8%)
Triage acuity	
Higher	15,140 (4.7%)
Intermediate	137,291 (42.8%)
Lower	168,448 (52.5%)
Arrival by ambulance	56,822 (17.8%)
Operational indicators for shift during which study cases presented	
On-duty EM physician *n* on patient arrival (median, IQR)	
Total	26 (23-28)
Consultants	6 (5-7)
Specialists	12 (10-14)
Fellows (EMFs)	5 (3-8)
Senior Residents	2 (1-3)
EMF proportion of on-duty Emergency Department (ED) physicians	
Median	22.2%
Range	0-51.9%
IQR	13.6-29.6%
Ambulance arrival cases (median, IQR)	82 (70-93)
Cases admitted to the hospital	30 (24-35)
Boarding patients (inpatient admits still in ED, awaiting bed)	43 (32-52)

Table-2: Length of stay for cases seen only by the Emergency Medicine (EM) service and discharged

Length of stay (LOS) median (IQR)	190 (99–333)
Quantiles of LOS (reported with 95% confidence interval)	
10th %ile (τ 10 for quantile regression)	52 (51–52)
20th %ile	83 (83–84)
30th %ile	115 (115–116)
40th %ile	150 (150–151)
50th %ile (median)	190 (189–191)
60th %ile	238 (237–239)
70th %ile	296 (295–297)
80th %ile	376 (374–377)
90th %ile (τ 90 for quantile regression)	497 (495–498)

Table-3: Emergency Medicine (EM) Fellow % of on-duty Emergency Department (ED) physicians as a predictor of ED length of stay for patients seen only by the EM service and discharged (LOS$_{DCEM}$)

LOS$_{DCEM}$ quantile (τ)	β,EM fellow % (95% confidence interval)	p
10	-6.5 (-9.5 to -3.5)	<.001
20	-6.4 (-9.9 to -2.8)	<.001
30	-7.3 (-11.7 to -2.9)	0.001
40	-4.9 (-10.2 to 0.51)	0.076
50 (median)	-6.0 (-12.3 to 0.4)	0.066
60	-2.4 (-9.3 to 4.5)	0.500
70	0.6 (-7.8 to 9.1)	0.883
80	5.1 (-4.8 to 15.0)	0.317
90	-9.8 (-25.6 to 6.1)	0.223

APPENDIX

The table below depicts the full results for each of the nine quantile regression models for the dependent variable LOS$_{DCEM}$. The column names indicate the τ level for the model (*e.g.* τ 10 corresponds to the quantile regression model at the 10th percentile of LOS$_{DCEM}$). If a covariate's β estimate is not included in a given model's report in the table, that covariate was not significant at the $p < .05$ level and was thus not included in the model.

Variable (all p ≤.001 unless otherwise noted)	Percentile of ED length of stay (patients discharged by Emergency Medicine service)								
	10	20	30	40	50	60	70	80	90
Patient factors									
Male		8.9	20.1	31.9	45.3	58.7	72.6	85.6	93.5
Age group: One-level increase	13.8	27.5	42.6	57.9	74.6	91,8	111.9	138	176.8
Arrival at the ED by ambulance	37.7	48.4	55.8	61.4	66.5	71.8	77.2	81.6	86.6*
One-level decrease in triage acuity	-1.3						-4.2	-9	-22.5
Operational (shift-level) factors									
Total number of on-duty physicians				-0.41	-0.86	-1.2	-2	-2.9	-4
# patients (all types)	0.06	0.09	0.13	0.15	0.19	0.22	0.26	0.27	0.3
# of ambulance arrivals	0.1	0.14	0.18	0.22	0.24	0.21	0.21	0.26	0.22*
# of ED boarders	0.09	0.13	0.16	0.15	0.08*		-0.13	-0.22	-0.29
Shift occurrence on a Friday		-2.4*	-4.8	-8.4	-12.4	-19	-28.9	-38.4	-44.9
One-level later shift (day to evening to night)	7.9	11.3	12.1	11.8	12	11.7	10.1	7.2	7.5
Study week	-0.09	-0.12	-0.1	-0.06*			-0.08*	-0.24	-0.37
p value of variable, if not ≤.001		*p = .003		*p = .019	*p =.003		*p = .023		* p = .002

DISCUSSION

The use of ED operations endpoints such as time intervals is a common method to gauge efficiency of acute-care delivery. Among the time intervals of interest is the duration of time between a patient's initial presentation and their disposition from the ED.[6] For the subset of those patients who were seen and evaluated by the EM service only (i.e. without consultation from another clinical service), this time interval was defined as the LOS$_{DCEM}$. Many other ED-related time intervals are of operational importance, but the LOS$_{DCEM}$ offers a study-focus advantage of being less impacted by factors (e.g. consulting-service response time) that lie outside the control of EM.

Before moving to discussion of this investigation's findings, some framing points should be considered. First, as a retrospective database analysis, the study's primary goal was to give a general sense as to whether a proportional increase in EMFs as a % of on-duty physicians impacted LOS in discharged cases. The study's aim was not generation of highly precise predictive models; the goal was less quantitative than qualitative (*i.e.* determination of presence and direction of EMF influence on LOS). The modelling in this study is presented as a general guide to assist answering the general question "Do EMFs speed up or slow down the ED disposition of discharged cases?"

The study's LOS$_{DCEM}$ was not at the ideal level, but it was not too far from some other EM analyses. A Swiss group, for instance, reported on ED-discharged cases and found a baseline ED stay duration of 176 minutes.[6] By increasing physician

manpower, the Swiss were able to achieve modest reductions (about a half-hour) in LOS for discharged patients, but not for admitted cases.[6] The Swiss findings support this study's *a priori* decision to focus on discharged cases as particularly likely to be influenced by EM physician parameters.

A second overarching point and study limitation is the EMR database used as the sole source of study timing information. The advantages (particularly related to objective, non-biased data) and disadvantages (particularly related to lack of potentially important variables) seen with EMR timing information is well-characterized in the EM evidence base.[3,7,8] In this study, a decision was made to include only those discharged cases with LOS under 24 hours, and only cases seen by EM without consultation by any other service. While such cases did represent a preponderance of the study centre's ED population, the patient definitions should be carefully considered when attempting to interpret study results.

There were doubtless factors that were not assessed, that could have confounded the possible association between EMF proportions and LOS_{DCEM}. ED construction at the study centre was ongoing during the study year, and while the analysis used calendar week (after the fashion of previous work)[3,9] to try and control for ED layout changes, the calendar-based surrogate is imperfect at best. Perhaps the most important potential confounder was case mix. All physicians in the study ED work in all areas of the department, so the potential for confounding by case mix was likely low. Nonetheless, the inability (due to limitations of the EMR database) to adjust for patients' specific diagnoses leaves room for confounding by different patient types.

The study limitations included one concern that could bias the results away from those that were identified. It is possible that EMFs, as compared to less-trained ED physicians, would be less likely to consult other clinical services for borderline cases. For instance, in a given case where an EM Specialist would consult Orthopaedics, EMFs may be more likely to perform fracture reduction themselves and leave the consultation to occur in the setting of outpatient follow-up. The current study design did not allow for reliable assessment of whether EMFs' presence was associated with an overall increase in consultation to other services, but this subject seems appropriate for further evaluation in the future.

The differential conclusions regarding EMF proportions and LOS_{DCEM} influence were drawn based on quantile regression. Quantile regression fits conditional quantiles of the response variable without presuming a normal error distribution for that dependent variable. It is useful for modelling performance not just at the dependent variable's central tendency but also for situations in which the dependent variable is substantially greater or lesser than its average value. Although computationally intensive[10] (a four-core multiprocessor version of Stata still required nearly an hour to run some of this study's models), quantile regression has established utility in the ED operations evidence base as a method to model the entire conditional distribution of the dependent variable (rather than just its mean, as is the case with OLS).

Conclusion: The LOS_{DCEM} does not appear to be unfavourably impacted by increasing the proportion of EMFs as a % of all on-duty ED physicians. These results are noteworthy because they account for overall physician numbers, and because EMF proportions were increased by commensurately reducing the on-duty proportions of board-certified independently practicing Specialist-grade physicians (Consultant and resident numbers were low and non-variable). There was no prolongation of LOS_{DCEM} at any level of patients' LOS_{DCEM}, and at the faster levels of LOS_{DCEM} there was strong statistical support for a conclusion that increasing EMF proportions sped discharge of those cases who did not require admission or other-service consultation.

The study suggests that increasing EMFs numbers (as a percentage of all on-duty physicians) disproportionately improves LOS_{DCEM} for those patients with shorter LOS.

AUTHORS' CONTRIBUTION

ST, DJ, AA: Dealt with concept, data collection, data analysis and data interpretation. AK, KB, TK: Literature search. SF, SP: Manuscript writing.

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