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The effect of vertical split-flow patient management on emergency department throughput and efficiency☆

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ABSTRACT

Background: To address emergency department overcrowding operational research seeks to identify efficient processes to optimize flow of patients through the emergency department. Vertical flow refers to the concept of utilizing and assigning patients virtual beds rather than to an actual physical space within the emergency department to care of low acuity patients. The aim of this study is to evaluate the impact of vertical flow upon emergency department efficiency and patient satisfaction.
Methods: Prospective pre/post-interventional cohort study of all intend-to-treat patients presenting to the emergency department during a two-year period before and after the implementation of a vertical flow model.
Results: In total 222,713 patient visits were included in the analysis with 107,217 patients presenting within the pre-intervention and 115,496 in the post-intervention groups. The results of the regression analysis demonstrate an improvement in throughput across the entire ED patient population, decreasing door to departure time by 17 min (95% CI 15–18) despite an increase in patient volume. No statistically significant difference in patient satisfaction scores were found between the pre- and post-intervention.
Conclusions: Initiation of a vertical split flow model was associated with improved ED efficiency.
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1. Introduction

To address overcrowding, systematic operational research has focused on optimizing emergency department (ED) throughput to meet the increasing demand for ED services [1-2]. An underlying tenant of this research is to identify operational strategies that improve overall ED efficiency by rearranging a limited amount of resources. One such strategy, the split-flow model, has been adopted throughout the United States to accomplish this goal [3-4, 5-15]. Traditional ED flow and triage attempt to identify and treat the sickest of patients preferentially over those who have less severe conditions. In the setting of ED crowding, this often results in prolonged wait time for those patients with lower triage acuity. Split-flow attempts to address this issue by creating a separate "fast track" for those patients of such lower acuity (Emergency Service Index (ESI) scale 4 or 5) [16]. These "fast track" areas have been well described [5-15] and can decrease total ED length of stay (LOS) to less than an hour in a select group of patients [17].

Vertical split-flow seeks to further ED efficiency in these low acuity patients. Traditionally, patients wait for a stretcher or room to be assigned to them within the ED. Once the patient goes to their assigned beds, they remain "horizontal." It is in this physical space that the entirety of the ED visit takes place: provider interview and evaluation, radiographic and laboratory tests, treatment, as well as discharge planning and education occur until disposition. In this setting, the limiting resource for patient flow is often the number of available beds. Vertical flow refers to the concept of utilizing and assigning patients virtual beds rather than to an actual physical space within the ED. Intake, formal triage, and provider exam may be completed utilizing multidisciplinary teams in order to minimize redundancy [18]. Once team intake is complete, the patient is moved to a sub-waiting or treatment area for lab and radiographic testing as well as any specific treatments. The physical exam room is then immediately available for the next patient and become high volume rotator rooms. When appropriate, the patient is then moved to a discharge area to discuss follow-up, return instructions, and answer any remaining questions.

2. Hypothesis

Replacing a traditional horizontal fast track with a vertical split-flow model managed by ED teams improves ED efficiency and patient satisfaction while remaining staffing neutral.

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3. Methods

3.1. Study design

This was a prospective pre/post-interventional cohort study of all intend-to-treat patients presenting to the ED during a two-year period before and after the implementation of a vertical flow model. The ED is a tertiary care and level 1 trauma center which serves as a training/educational site for hospital house staff, an Emergency Medicine advanced practice provider training program, Graduate Nurse internship program, and Nurse/Paramedic School Clinical site. The 74 bed ED is augmented by an ED managed observation unit. Inpatients are boarded on a daily basis in the ED. All pediatric, severe burn, and psychiatric admissions are transferred to other facilities.

3.2. Patient participants

All consecutive patients presenting to the ED during the study period were considered eligible for study inclusion. The census and patient mix presenting to the ED have hourly, weekly, and seasonal variation [20]. In order to compare cohorts with baseline demographics as similar as possible, a 12-month time period was used to evaluated length of stay for each cohort.

3.3. Intervention

During the pre-intervention period, the ED operated utilizing a split flow model whereby all ESI 4 and 5 patients would be placed in a fast track area. All fast track patients were seen by an advanced practice provider at a site adjacent to the main ED within the hospital. Registration, triage, and imaging studies were performed in the same manner within the fast track and main ED. Patients receiving ESI levels of 1, 2, or 3 were triaged and, if available, bedded in 1 of 5 pods that make up the main ED of 74 beds. If no beds were available, patients were placed in the main waiting room and then selected for bed placement based upon ESI level, nursing judgment and arrival time. During the pre-intervention phase, the main ED used several adjunct processes to improve intake [4]. These included "pull-to-full," whereby, patients were placed in available beds prior to full triage evaluation allowing the primary nurse to complete this task, bedside registration, and electronic tracking and charting system [4]. Patients within the main ED would be evaluated by the attending Emergency Medicine physician and/or an advanced practice provider. All attending physicians were either board eligible or board certified by the American Board of Emergency Medicine.

After 12 months of the pre-intervention period, a vertical split flow model was instituted throughout the entire ED. To accomplish this an existing pod comprising 10 patient beds, a sub-waiting area capable of seating approximately 15 people, and a treatment area consisting of 4 curtained beds, was reassigned to vertical flow. The adjacent fast track area was closed, removing 10 beds from within the total ED pool, and the fast track staff (18 h of advanced practice provider coverage, 18 h of ED technician, and 36 h ED nursing) were moved to the vertical flow area (VFA). Fast track staff combined with the existing pod staff to form 2 ED teams, as well as a float/treatment nurse and a "flow nurse" who was responsible for identifying appropriate patients in triage, following up on pending results, and ensuring overall smooth flow through the VFA. Patients were identified as eligible for vertical flow at the time of initial check in by the intake triage nurse. This triage nurse would be tasked with obtaining patient complaint, pulse oximetry reading and pulse rate, and quickly assigning an initial ESI level. Patients with an ESI level 3, 4, or 5 who could sit and did not require monitoring were placed in the vertical flow quay. If bed space was available VFA patients were triaged at the bedside, in the event the VFA was full, triage would occur in the triage area. Then the patient was placed in a room for evaluation sorted by arrival time. In the setting of moderate and severe ED overcrowding, the VFA remained protected from being converted into horizontal beds. If the ED was full and an EMS patient arrived with a critical patient, the patient was not bedded in the VFA as this area was constantly used for lower acuity throughput.

3.4. Outcomes

Clinical variables were extracted from the medical records. A pre/post-cohort analysis was completed comparing time intervals with the primary outcome being median ED LOS. Secondary outcomes included differences in arrival to provider time, disposition decision to departure, the percentage of patients who left without being seen and who left before treatment complete, and patient satisfaction scores were calculated for each cohort [19].

3.5. Data analysis

All statistical analyses were performed using STATA 14.2 (College Station, TX). Demographic and outcome variables were compared between the pre- and post-vertical flow groups. Multiple linear regression was performed to adjust for age, gender, patient level of acuity (ESI), type of ED disposition (discharge, admission, and others) and then compared using 95% confidence intervals (CI) for differences in median or proportions for independent groups. This study was approved by the institutional review board with a waiver of informed consent.

4. Results

In total, 222,050 patient visits were included in the analysis with 107,217 patients presenting within the pre-intervention and 114,833 in the post-intervention groups. Demographics of the groups are presented in Table 1. The overall admission rate was 19.3%. Patients in the pre-intervention group were younger and more likely to be ESI level 1 or 2, and admitted to the hospital. During the study period, no organized effort was made to change practice patterns of the provider groups with regard to admission to the hospital.

Due to differences in demographics between the pre- and post-intervention groups, multiple linear regression was performed to account for the impact upon throughput times. After adjusted for potential confounders including age, gender, level of acuity, and patient ED disposition, the regression coefficient of intervention was −9.8 (95% CI −10.9, −8.8) for provider to disposition time and coefficient of intervention was −18.9 (95% CI −20.2, −17.6) for entire ED LOS separately. This indicates that an improvement of shortened ED duration occurred with the implementation of interventions. Additionally, study results also demonstrated an improvement in throughput across the entire ED patient population with the decrease of provider to disposition time by 12 min and subsequently decreasing the entire ED LOS by 17 min despite an increase in patient volume. The differences in throughput times are presented in Table 2.

Table 1
Pre- and post-cohort demographics.

	Pre (N = 107,217)	Post (N = 114,833)
Age in years, median (IQR)	41 (26–57)	42 (26–57)
Gender, female (%)	60,438 (56)	65,165 (57)
Pediatric (%)	9157 (8.5)	8423 (7.4)
ESI: 1, 2 (%)	38,552 (35.9)	36,849 (32.1)
Outcome (%)		
Admit	21,303 (19.9)	21,506 (18.7)
LWBS & eloped	3513 (3.3)	4004 (3.5)
Expired	307 (0.29)	307 (0.27)
Discharge	77,429 (72.2)	83,784 (73.0)
Other (transfer, left AMA)	4608 (4.3)	5232 (4.6)

ESI: Emergency Severity Index. LWBS: left without being seen. AMA: against medical advice.

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