

Analysis of the Literature on Emergency Department Throughput

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Introduction: The purpose of this paper was to review and analyze all the literature concerning ED patient throughput. The secondary goal was to determine if certain factors would significantly alter patients' ED throughput.

Methods: A MEDLINE search was performed from 1966 to 2007 using the terms "turnaround," "emergency departments," "emergency medicine," "efficiency," "throughput," "overcrowding" and "crowding." Studies were graded using a scale of one to four based on the ACEP paper quality criteria. Inclusion criteria were English language and at least a level four or better on the quality scale. An analysis of successful procedures and techniques was performed.

Results: Literature search using the key terms found 29 articles on turnaround times, 129 on ED efficiency, 3 on throughput, 64 on overcrowding and 52 on crowding. Twenty-six articles were found to meet the inclusion criteria. There were three level I studies, thirteen level II studies, five level III studies and five level IV studies. The studies were categorized into five areas: determinants (7), laboratories processes (4), triage process (3), academic responsibilities (2), and techniques (10). Few papers used the same techniques or process to examine or reduce patient throughput precluding a meta-analysis.

Conclusions: An analysis of the literature was difficult because of varying study methodologies and less than ideal quality. EDs with combinations of low inpatient census, in-room registration, point of care testing and an urgent care area demonstrated increased patient throughput.
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INTRODUCTION

Improving efficiency and throughput in the emergency department (ED) has multiple benefits. Better efficiency should increase patient satisfaction, enhance revenue and reduce ambulance diversion. The need to focus on ED efficiency has become more acute in recent years due to increasing litigation, including a case where a patient in Chicago died while waiting for care.¹

EDs across the U.S. struggle to provide efficient care in a timely fashion. Increasing patient volumes, a reduction in the number of EDs, higher inpatient census and ED staff reduction all exacerbate the struggle. The purpose of this

paper is to review the literature and summarize strategies used nationwide to deal with this crisis. Proven techniques could be used by hospital and ED managers.

METHODS

We searched MEDLINE from 1966 to March 2007 for English language articles using the keywords *turnaround*, *efficiency*, *throughput*, *overcrowding* and *crowding*. No other restrictions in the search fields were used. We also reviewed references from these articles to ensure that we included all possible studies.

We required one or more factors related to throughput to

Table 1. Literature classification schema*

Class	Design	Diagnosis	Prognosis
1	Randomized, controlled trial	Prospective cohort using standard metrics	Population prospective cohort
2	Nonrandomized	Observational	Case control
3	Case series, case report, consensus	Case series, case report, consensus	Case series, case report, consensus
4	Expert opinion, design flaws, incomplete data	Expert opinion	Expert opinion

* Adapted from: American College of Emergency Physicians/Physician Consortium: Emergency medicine physician performance measurement set.²

include an article in further analysis. We used a classification system modified from the American College of Emergency Physicians to assess the study's methodology and quality.² To be more inclusive in the review, a fourth parameter was added to the classification system (Table 1). Each article was graded one to four based on this classification scheme. Those studies with confounding variables, problematic study design, limited data or poor presentations were downgraded to the next lower class. Due to the lack of uniformity and consistency within the literature, studies of similar design and technique could only be identified and grouped into five broad categories: throughput determinates, academic responsibilities, laboratories, triage, and techniques. A table of the findings was produced to summarize the class, design, analysis, conclusion and limitations of each study (Table 2).

RESULTS

The literature search using the keywords crossed with "emergency departments" and "emergency medicine" (EM) found 29 articles related to *turnaround*, 129 articles related to *efficiency*, four articles related to *throughput*, 52 articles related to *crowding* and 64 articles related to *overcrowding*.

Twenty-six articles were found to meet the inclusion criteria. Studies that lacked data, had poor scientific design or provided limited information were not rated. There were three level I studies, 13 level II studies, five level III studies and five level IV studies (Table 2). We then sorted them, using the five broad categories throughput determinants (seven articles), laboratories processes (four articles), academic responsibilities (two articles), triage process (three articles), and throughput reduction techniques (10 articles).

Throughput Determinants

Several articles focused on the correlation between throughput time and ED factors. The articles showed that ED length of stay (LOS) increased substantially with increased admissions, number of ambulance arrivals, number of pediatric patients and ED census.³⁻⁸ Rathlev et al.⁸ found that daily mean LOS was increased not only by number of ED admission and hospital occupancy but also by elective surgical admission. Interestingly, two of the studies did not find a significant correlation between the throughput time and hours

of nursing coverage, day of the week or urgent care hours.^{3,4} Saunders et al.⁹ performed a computer simulation study of ED operations and found that throughput times correlated directly with laboratory service times and inversely with number of physicians and nurses. This latter relationship had a ceiling where a continued increase in providers demonstrated no change in throughput time.⁹

Academic

Two studies examined the effect of teaching on ED throughput. Chan et al.¹⁰ examined how medical students affected ED throughput and found that fourth year medical students' precepting for four weeks in the ED did not change the LOS for patients. A similar study¹¹ looking at the effects of adding EM residents found that the residents increased the total throughput time an average of seven to 39 minutes.

Laboratories

In a study of 11 hospital EDs, Holland et al.¹² found that addressing the laboratory outliers rather than the mean turnaround time can reduce the ED LOS. In a study of 690 hospital laboratories, Steindel and Howanitz¹³ found that faster throughputs were related to lab control of the specimen handling and rapid transport times. Murray et al.¹⁴ performed a randomized controlled trial comparing point-of-care testing to central laboratory testing and found that point-of-care testing reduced the median stay by 54 minutes. Study supplies and equipment but not grant funding were provided for this potentially biased study. In a comparison study of the use of a pneumatic tube delivery system versus human couriers, Fernandes et al.¹⁵ found that a tube system reduced lab reporting time by 8-10 minutes.

Triage

Partovi et al.¹⁶ compared the LOS in triage with and without an emergency physician, and found an 18% reduction in LOS when a physician began patient evaluation and treatment in triage. This paper reported a significant cost of physicians in triage, which may outweigh the benefits of reduced LOS. Choi and Claudius¹⁷ studied the use of pulse oximetry on bronchiolitis patients in triage and found that it could reduce throughput by 50 minutes. The authors did not

study the reason for decreased throughput time nor describe how the evaluation and treatment may have been altered with pulse oximetry measurement; however, they suggested that identification of hypoxia changes management, and proper patient placement to urgent care or main ED may have accounted for this time reduction.

Techniques

Multiple studies described techniques used to reduce ED LOS. Spaite et al.¹⁸ examined one ED that employed a rapid process redesign, and found that it led to a 76-minute reduction in average patient LOS. The rapid redesign focused on staffing and internal processes, triage and registration procedures and diagnostic radiology, laboratory and bed availabilities. This rapid improvement process occurred over three months and cost the hospital over \$1 million annually. This cost was offset by increased revenue, providing a net annualized profit of \$300,000. Purnell et al.¹⁹ surveyed 185 hospitals and found that an urgent care unit reduced patient wait times by 20%. This limited survey study performed in 1989 found that the mean wait time was 72 minutes in EDs with fast track and 90 minutes for those without.

In a comparison of multiple interventions, Cardin et al.²⁰ found that increased emergency physician (EP) coverage, designation of a physician coordinator and changes in hospital policies on laboratory, consultations and admission procedures could reduce ED mean LOS from 13.8 hours to 5.9 hours. The article focused on the effect of the interventions on return visits and hospital readmissions and not on the interventions used and associated costs. There were ten total interventions noted in the appendix with transfer-to-ward within one hour of bed assignment having the most impact.

Patel and Vinson²¹ used an ED team concept, which joined an EP with two nurses and one technician. This novel change led to improved patient satisfaction with an increase of 3.1% in reported “very good” or “excellent” ratings, a reduction in the time required to see a physician, a 7.7% increase in number of patients seen within one hour, and a 0.7% decrease in patients who left without being seen.

Another published approach to reducing the ED LOS was to use a 72-hour admission unit on an existing medical unit with 16 beds designated for ED overflow patients.²² This study, which used a short-stay, 72-hour unit found that chest pain and asthma patients had a significant reduction in ED throughput times. Mean ED time was reduced from 7.3 to 5.5 hours per chest pain patient, and 5.0 to 2.9 hours per patient with asthma; however, patients with sickle-cell disease or seizures showed no decrease. The article notes that no other changes in protocols, staffing or processes occurred during the study period. Although this study examined the effect of a short stay unit, in essence it was evaluating the effect of increased inpatient capacity on LOS in the ED. Gorelich, Yen and Yun²³ found that in-room registration reduced the length of ED stay by 15.0 minutes or 9.3%.

DISCUSSION

After a thorough review of the literature, we were unable to find consensus on techniques to improve ED efficiency and thereby decrease LOS. This is most likely due to environmental, demographic, or institutional variations. One could conjecture that there are significant differences between teaching and non-teaching, small community versus large university, trauma versus non-trauma centers, and large-volume versus small-volume hospitals that prevent agreement on specific techniques. In other studies, the conclusions were not intuitive or widely accepted. For instance, two studies found that residents slowed patient throughput but medical students did not. Unfortunately, there are no comparisons of those institutions with both medical students and residents, level of student or residents, or the effect of residents from other services.

Despite a lack of consensus, this analysis demonstrates that there are a number of scientifically-based procedures to reduce ED patient LOS that could be useful. Certain strategies appear to be universally accepted. These include pulse oximetry determination in triage, bedside registration, point-of-care testing, use of an urgent care area, and efficient lab, radiograph and hospital admission processes. Furthermore, the use of physicians in triage was found to be effective, although a cost versus benefit analysis is needed. The ability to apply and implement many of these procedures in other EDs is dependent on local factors, politics and resources.

Many other articles were reviewed that were not included in this study either because they did not meet the study requirements or were not found in MEDLINE. The study required that the article include some type of research rather than a description of process improvement techniques. Valuable information on throughput is frequently published in hospital or management journals that discuss process improvement.

Based on a review of the literature on reducing patient LOS in the ED, the best means for improvement is first to select the appropriate determinants that drive patient throughput at the local level, such as number of admissions, number of ambulance arrivals and ED census, and then review and revise the processes that drive the throughput determinants and monitor the data to ensure that the changed processes accomplish the goal to improve throughput.

In the author’s experience, the critical success factors to implement the necessary changes were to obtain accurate and timely throughput data to review, obtain buy-in to the process from senior management as well as staff who will have to implement the changes, and determine what the cost/benefit ratio will be. At the author’s hospital, LOS was reduced by 31% and the left-without-treatment rate was reduced from 10% to 2% without any additional costs in a three-month time period. The keys to success were a rapid redesign process involving all hospital departments and services, as well as senior management and line staff, using accurate and correct ED data and having managers focus on a self-initiated process improvement methodology.

Table 2. Analysis of literature

Reference	Study Class	Study Design/ Operational Area	Analysis	Conclusion	Comments/Limitations
Chan, Kass; 1999.	1	Prospective consecutive Academic	Compared days with students to those without	Medical students do not alter the throughput times.	Average throughput was 145 minutes with and 151 without students. Multiple biases limited the study.
Murray et al.; 1999.	1	Randomized, controlled study Laboratory	Compared central lab to point-of-care testing	Point-of-care testing significantly reduced LOS.	Average LOS for central lab was four hours 22 minutes and point-of-care testing was three hours 28 minutes. Reduced time was found only in discharged patients.
Partovi et al.; 2001.	1	Comparison study Triage	Compared impact of faculty doing triage to nurse only	Moderate reduction in LOS.	Average LOS with faculty was 363 minutes and 445 minutes with nurses. Faculty was added to complement nurses.
Asaro, Lewis, Boxerman; 2006.	2	Observational trial Determinants	Twenty-seven month analysis of input/output variables for ED throughput	Determine process outcomes and ED inputs and bottlenecks.	Average main LOS 445 minutes, urgent 265 minutes, entire 385 minutes. Significant differences found between 20 and 80 percentile ED arrivals
Chan et al.; 2005.	2	Before and after trial Determinants	Compared before and after change in IT, staff revisions and culture change	Value in rapid ED entry process.	Pre to post reduction of 31 minutes. Average LOS was five hours. Process change was not well described.
Fernandes et al; 2006.	2	Cross-sectional study of an institution with and without tube system	Compared two EDs, one with pneumatic tube system and one with human couriers	Reduced lab turnaround from 8-10 minutes for Hgb and K with pneumatic tube system.	Average turnaround time varied from 33 to 72 minutes. Courier was called to transport specimens. Limited by two EDs in Canada.
Liew et al.; 2003.	2	Retrospective review Determinants	Compared ED LOS to hospital	ED LOS correlates strongly with inpatient LOS.	Average ED LOS was 7.96 hours and hospital LOS was 5.63 days. Australian study.
Lammers et al.; 2003.	2	Before and after observational Academic	Compared before residents versus after residents	Weak correlation between presence of PY-3s and LOS.	Average LOS before residents was 123 minutes and 162 minutes at year three.
Choi, Claudius; 2006.	2	Before and after study with and without triage pulse oximetry. Triage	Compared pre-intervention versus post intervention	Reduced throughput by 50 minutes.	Average turnaround for pediatric bronchiolitis patients pre-intervention 159 minutes and post-intervention was 89 minutes.
Cardin et al; 2003.	2	Before and after study of multiple interventions. Techniques	Compared change in increased MD coverage, MD coordinators, and new policies	Multiple interventions reduced the mean LOS by 7.9 hours.	ED LOS reduced from 13.8 hours to 5.9 hours. Limited by multiple interventions in Canada.
Patel, Vinson; 2005.	2	Before and after comparison Techniques	Team assignments effect on patient throughput	Throughput times reduced by 9.5 minutes.	Average throughput varied from 239-257 minutes. Limited by multiple personnel changes during study periods.

Table 2. Analysis of literature

Reference	Study Class	Study Design/ Operational Area	Analysis	Conclusion	Comments/Limitations
Rathlev et al.; 2007.	2	Retrospective review Determinants	Moving averages and independent variables	Additional elective surgery - 21 minutes, additional admission - 2.2 minutes, every 5% increase in hospital occupancy - 4.1 minutes.	Mean LOS 241 minutes. Limited number of variables examined.
Bazarian, et al.; 1996.	2	Before and after study Techniques	Effectiveness of short stay unit	Reduced number of patients waiting to go up from 9.6 to 2.3 patients per day.	Average LOS reduced from 6.5 hours to 5.6 hours. One hospital trial.
Gorelick, Yen, Yun; 2005.	2	Before and after study Techniques	Compared ED LOS to in-room registration.	In-room registration reduced LOS.	Average LOS was reduced by an average of 15 minutes. Average length of ED LOS 2.2-3.8 hrs.
Chan, Reilly, Salluzo; 1997.	3	Observational study Determinants	Tracked eight variables	Throughput times dependent on inpatients, daily census, pediatric volume, ambulances.	Average throughput 330 minutes for admitted and 123 for discharged. The correlation coefficients ranged from .54-.32.
Steindel, Howanitz; 2001.	3	Survey study of physicians done by pathologists Laboratory	Compared turnaround time for 690 hospital laboratories	Reduced turnaround times for labs correlated with lab-controlled specimen handling and rapid transport time.	Average order to reporting time mean was 50-60 minutes. Limited by survey study.
Foster et al.; 2003.	3	Retrospective database review Determinants	Daily hospital occupancy	Daily ED LOS increased by 18 minutes with a 10% increase in occupancy.	Average throughput was 354 minutes for admitted patients. Canadian study limited by lack of correlation coefficients.
Spaite et al.; 2002.	4	Before and after comparison Techniques	Multiple factors very varied and the effect on throughput studied.	Throughput times decreased by 76 minutes.	Average throughput time was 175 minutes. Limited by multiple factors and descriptive study design.
Saunders, Kaens, Leblanc; 1989.	4	Computer simulation Determinants	Varied number of nurses, physicians, treatment beds and blood turnaround time.	Increasing number of nurses and physicians increased throughput. Number of exam rooms had no effect. Laboratory time had a direct effect.	A number of variables not taken into account. Computer simulation.
Holland; 1991.	4	Observational study Laboratory	Surveyed 11 hospitals	ED LOS was correlated with total lab outliers rather than lab turnaround times.	No throughput times provided for the ED.
Purnell; 1991.	4	Survey study techniques	Analyzed hospitals throughput time with and without fast track	Facilities with a Fast Track had reduced waiting time by 18 minutes.	Average waiting time with Fast Track was 72 minutes and without Fast Track was 90 minutes. Unvalidated survey sent to some east coast hospitals.

ED, emergency department; *LOS*, length of stay; *IT*, information technology.

LIMITATIONS

These data could not be tabulated to perform a meta-analysis because of diverse study designs and the marginal quality of the papers. In general, the research methodology in these administrative studies was not as rigorous as other scientific research. Most were observational or before-and-after studies, which included potential confounding variables. Additional factors to explain the problems with this type of research include lack of external funding, difficulty in isolating specific techniques to reduce LOS, or difficulty performing randomized interventions. The analysis of each article was scientifically based, but there was always the possibility of rater bias. Lastly, the grouping of study topics was arbitrary but necessary to determine trends and commonalities.

CONCLUSIONS

The world's ED throughput literature is limited in applicability from one institution to another; however, there do appear to be some overarching alterations in behavior that will serve to speed patients through the ED. Useful strategies include improvements in triage, urgent care centers, point-of-care testing and bedside registration.

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