Analysis of factors influencing length of stay in the emergency department

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ABSTRACT

Objectives: Length of stay (LOS) is a key measure of emergency department (ED) throughput and a marker of overcrowding. Time studies that assess key ED processes will help clarify the causes of patient care delays and prolonged LOS. The objectives of this study were to identify and quantify the principal ED patient care time intervals, and to measure the impact of important service processes (laboratory testing, imaging and consultation) on LOS for patients in different triage levels.

Methods: In this retrospective review, conducted at a large urban tertiary care teaching hospital and trauma centre, investigators reviewed the records of 1047 consecutive patients treated during a continuous 7-day period in January 1999. Key data were recorded, including patient characteristics, ED process times, tests performed, consultations and overall ED LOS. Of the 1047 patient records, 153 (14.6%) were excluded from detailed analysis because of incomplete documentation. Process times were determined and stratified by triage level, using the *Canadian Emergency Department Triage and Acuity Scale* (CTAS). Multiple linear regression analysis was performed to determine which factors were most strongly associated with prolonged LOS.

Results: Patients in intermediate triage Levels III and IV generally had the longest waiting times to nurse and physician assessment, and the longest ED lengths of stay. CTAS triage levels predicted laboratory and imaging utilization as well as consultation rate. The use of diagnostic imaging and laboratory tests was associated with longer LOS, varying with the specific tests ordered. Specialty consultation was also associated with prolonged LOS, and this effect was highly variable depending on the service consulted.

Conclusions: Triage level, investigations and consultations are important independent variables that influence ED LOS. Future research is necessary to determine how these and other factors can be incorporated into a model for predicting LOS. Improved information systems will facilitate similar ED time studies to assess key processes, lengths of stay and clinical efficiency.

Key words: emergency department, length of stay, *Canadian Emergency Department Triage and Acuity Scale*, CTAS

RÉSUMÉ

Objectifs : La durée de séjour est un paramètre clé du débit à l'urgence et un marqueur de l'encombrement. Les études des délais axées sur l'évaluation des processus clés à l'urgence permettront de clarifier les causes des délais des soins aux patients et des durées de séjour prolongées. La présente étude avait comme objectifs d'identifier et de quantifier les principaux délais liés aux soins aux patients de l'urgence et de mesurer l'impact des processus des services importants

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Received: Aug. 12, 2002; final submission: Jan. 20, 2003; accepted: Jan. 30, 2003

This article has been peer reviewed.

Can J Emerg Med 2003;5(3):155-61

https://doi.org/10.1017/S1481803500006539 Published online by Cambridge University Press

(épreuves de laboratoire, imagerie et consultation) sur la durée de séjour pour les patients de divers niveaux de triage.
Méthodes : Lors de cette revue rétrospective menée dans un grand hôpital universitaire de soins tertiaires et de traumatologie, les chercheurs passèrent en revue les dossiers de 1047 patients consécutifs traités au cours d'une période ininterrompue de sept jours en janvier 1999. Les données clés furent notées, y compris le profil des patients, les délais à l'urgence, la nature des épreuves effectuées, les consultations et la durée de séjour globale. Parmi les 1047 dossiers, 153 (14,6 %) furent exclus en raison de documentation incomplète. Les délais des processus furent déterminés et stratifiés par niveau de triage, à partir de *L'échelle canadienne de triage et de gravité pour les départements d'urgence* (ÉTG). Une analyse de régression linéaire multiple fut effectuée pour déterminer les facteurs les plus étroitement liés à la durée de séjour prolongée.
Résultats : Les patients des niveaux de triage intermédiaires III et IV étaient ceux qui avaient généralement le plus long délai d'attente entre l'évaluation par l'infirmière et l'examen par le médecin, ainsi que la plus longue durée de séjour à l'urgence. Les niveaux de triage de l'ÉTG prédirent le recours aux services de laboratoire et à l'imagerie ainsi que le taux de consultation. Le recours à l'imagerie diagnostique et aux épreuves de laboratoire était associée à de plus longues durées de séjour à des degrés variables selon les épreuves demandées. La consultation d'un spécialiste était aussi associée à des durées de séjour prolongées à des degrés variables selon le service consulté.
Conclusions : Le niveau de triage, les investigations et les consultations sont des variables indépendantes importantes qui influencent la durée de séjour à l'urgence. Des recherches plus poussées sont nécessaires pour déterminer comment intégrer tous les facteurs dans un modèle de prédiction de la durée de séjour. Des systèmes d'information améliorés faciliteront des études de délai similaires pour évaluer les processus clés, les durées de séjour et l'efficience clinique.

Introduction

Overcrowded emergency departments (EDs), prolonged waiting times, patient care delays and scarce resources are common themes in current urban emergency medicine.[1,2] Patient length of stay (LOS) is a key measure of ED throughput and a marker of overcrowding. Previous studies have shown that overcrowding, prolonged waiting times, and protracted lengths of stay increase the proportion of patients who leave without being seen by a physician,[3,4] and that improved ED management processes, such as protocol-driven evaluation systems and reorganized clinical teams can significantly decrease LOS.[5,6]

Internal and external factors contribute to patient care delays. These factors include patient characteristics, ED staffing patterns, access to stretchers and health care providers, time of patient arrival, management practices, and testing and treatment strategies chosen.[7–12] Understanding the factors that contribute to ED process times and patient care delays is a critical step in improving ED patient care efficiency. Time study analyses of ED care processes are a potentially useful quality improvement tool and will help clarify and quantify the causes of patient care delays.[13–15]

Our objectives were to identify and quantify the key ED patient care time intervals for each triage level, and to estimate the effect of independent variables — particularly laboratory testing, diagnostic imaging and consultations — on ED LOS. Unlike previous ED time studies, our analysis relates empirical process data to the *Canadian Emergency Department Triage and Acuity Scale* (CTAS), a standardized national triage scale.[16]

Methods

Setting

This study was conducted at the emergency department of the University of Alberta Hospital, an urban tertiary care teaching hospital and designated regional trauma centre. At the time of data collection, the hospital was the only centre in northern Alberta that provided services for pediatric critical care, burn treatment, transplant medicine and neurosciences. The ED saw over 60 000 patients a year and was staffed by 2 attending emergency physicians, except for the period from 0100 to 1000 hours, when only one attending physician was present. This study received ethics approval from the University of Alberta Health Research Ethics Board.

Data collection

An investigator (P.Y.) manually reviewed the records from all patients who attended the ED between midnight Jan. 23, 1999, and midnight Jan. 29, 1999, a continuous 168-h

https://doi.org/10.1017/S1481803500006539 Published online by Cambridge University Press

period of study. Age, gender, registration time, mode of arrival (ambulance or walk-in), initial triage level, triage assessment time, nursing assessment time, physician assessment time, medical decision time (discharge vs. admit), time of departure, use of ancillary services (lab, x-ray, computed tomography, ultrasound, nuclear medicine), and use of specialty consultation services were recorded for each patient seen during the study period.

Time intervals

Five pre-defined time intervals, representing the main phases of ED assessment and treatment, were determined, and total LOS was calculated for each patient. The time intervals were: 1) from ED entry (registration) to triage nurse assessment, 2) from triage assessment to nursing assessment, 3) from nursing assessment to physician assessment, 4) from physician assessment to disposition decision (i.e., admission vs. discharge), and 5) from disposition decision to actual departure from the ED. In cases where the triage nurse did both the triage assessment and the nursing assessment, interval 2 (triage to nursing assessment) was considered to be 0 minutes. Admitted patients were not considered to have departed from the ED until they were physically transported out of the ED to the hospital inpatient ward or another patient care facility.

Data analysis

Data were recorded on standard study forms, then entered into an Excel spreadsheet (Microsoft Excel 2001 for Macintosh, Redmond [WA]: Microsoft Corp.; 2000). Patient demographics, triage levels, time intervals and selected variable relationships were described using descriptive statistics. Mean time intervals were compared using unpaired two-sample *t*-tests. Multiple linear regression analysis was performed to determine how various patient characteristics and ED service processes influenced LOS. For the regression model, LOS in hours was the dependent variable, and several independent variables were used to develop the model. These included mode of arrival, initial triage level, time of arrival (i.e., day [0800–1600], evening [1600–2400] or night [0000–0800]), use of laboratory tests, use of diagnostic imaging (x-ray, CT or ultrasound), specialty service consultation and disposition. Regression analyses were performed using the SPSS statistical software (SPSS Base version 10.0 for Macintosh, Chicago [IL]: SPSS Inc.; 1999).

Results

Study patients

During the 7-day study period, 1047 patients registered in the ED. Of these, 113 patient charts (10.8%) were excluded from analysis because of incomplete documentation and 40 (3.8%) were excluded because the patient left without seeing a physician. The mean age of study patients was 38.3 years (standard deviation [SD] = 23.8 yr) and 51% were male. Ninety-three percent fell into triage Levels III, IV and V (Table 1). For the 894 patient visits analyzed, mean ED LOS was 271 min (SD = 173 min). Table 1 shows that the LOS distribution was bell-shaped: patients in triage Levels I and V had the shortest LOS, while those in Level III had the longest. Figure 1 shows that most patients spent 2 to 5 hours in the ED, 11.3% spent more than 9 hours, 5.0% spent more than 12 hours, and 0.3% spent more than 24 hours in the ED.

Time delays increased in the lower triage levels (Table 1). Registration-to-triage intervals ranged from 2.8 min to 13.9 min, with a mean of 11.0 min (SD = 13.7). Table 2 shows the mean registration-to-nursing assessment, mean registration-to-physician assessment intervals, and fractile response rates for each CTAS level.[16] The physician-related interval (between physician assessment

Table 1. Key emergency department process intervals (mean minutes), stratified by triage level*

Triage level	*n* (%)	ED registration to triage assessment	Triage assessment to nursing assessment	Nursing assessment to physician assessment	Physician assessment to disposition decision	Disposition decision to actual departure	Total ED LOS (SD)
I	9 (1.0)	2.8	0.4	1.6	67.0	79.6	151.3 (99.3)
II	55 (6.2)	2.6	4.5	7.5	190.8	95.4	300.8 (251.4)
III	297 (33.2)	7.7	12.7	32.8	245.9	67.4	366.4 (266.5)
IV	327 (36.6)	13.9	25.8	35.5	155.3	20.7	251.2 (199.0)
V	206 (23.0)	13.8	18.3	34.8	83.8	11.3	162.1 (173.0)
All	894 (100)	11.0	18.2	32.4	170.2	39.2	271.0 (173.0)

*Triage levels determined by the *Canadian Emergency Department Triage and Acuity Scale* (CTAS).
ED = emergency department; LOS = length of stay; SD = standard deviation

https://doi.org/10.1017/S1481803500006539 Published online by Cambridge University Press

and disposition decision) ranged from 67 min to 246 min, accounting for approximately two-thirds of the entire LOS. Once the decision to admit a patient was made by a consultation service, the average time necessary to physically transfer the patient out of the ED and to the appropriate hospital ward was 177 min (SD = 155 min), with a range of 10 min to 17.8 h. The admission rate during the study period was 22.6% (202/894). Table 3 illustrates that all forms of utilization, including lab or imaging tests, specialty consultations and admissions, increased from the lowest (Level V) to the highest (Level I) triage levels.

Considering a "baseline" patient as a Level V patient requiring no ancillary tests and no specialty consultation (mean LOS = 1.8 h), the multiple linear regression analysis showed that ultrasound imaging added 4.7 h (standard error [SE] = 1.0; $p < 0.001$), laboratory testing added 2.1 h (SE = 0.3; $p < 0.001$), x-rays added 1.0 h (SE = 0.2; $p < 0.001$) and CT added 0.7 h (SE = 0.4; $p = 0.09$) to ED LOS. Arrival by ambulance was associated with a 0.6-h increase (SE = 0.28; $p < 0.05$), but arrival time of day did not have a significant impact on LOS. Consultation prolonged LOS by a variable amount, depending on the consultation service (Table 4).

The complete regression model yielded an R^2 value of 0.384 (F = 16.76, $p < 0.001$). Examination of the correlation matrix of all the explanatory variables did not reveal any highly correlated variables (i.e., no variable had an absolute correlation coefficient >0.6). Removal of factors with coefficient t values that had significance levels >5% did not produce a superior model. Regression diagnostics showed no evidence of significant multicollinearity.

Discussion

This analysis demonstrates the utility of time studies in identifying and quantifying factors that prolong ED LOS. The CTAS[16] provides objectives for ED nurse and physician response times, as well as recommended fractile response rates — which refer to the proportion of patients in a given triage level who are assessed within CTAS re-

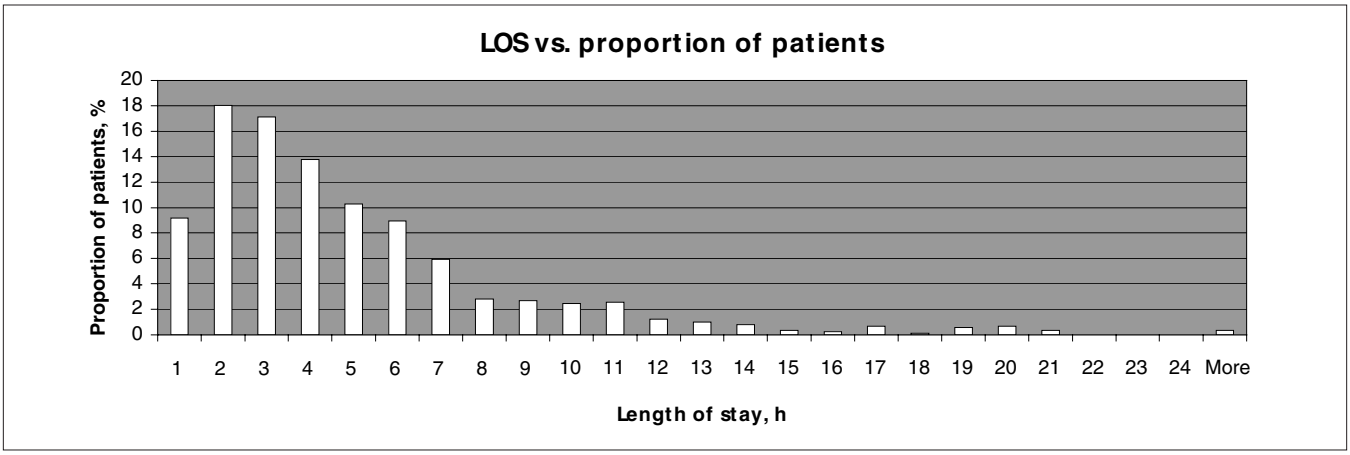

Fig. 1. Proportion of patients for various lengths of stay

Table 2. Comparison of nursing and physician response times in study with CTAS response time objectives

Triage level	Mean time from registration to nursing assessment		Nursing assessment fractile response, %	Mean time from registration to physician assessment		Physician assessment fractile response, %
	Study, min (SD)	CTAS objective , min		Study, min (SD)	CTAS objective, min	
I	3.2 (8.3)	5*	89	4.8 (9.6)	5*	89
II	7.1 (8.6)	5*	51	14.6 (12.3)	15	64
III	20.4 (21.8)	30	82	53.2 (40.0)	30	32
IV	39.7 (42.8)	60	82	75.2 (54.8)	60	50
V	32.2 (40.1)	120	96	67.0 (56.8)	120	84
All	29.2 (36.1)	–	–	61.5 (51.4)	–	–

SD = standard deviation; CTAS = *Canadian Emergency Department Triage and Acuity Scale*
*For the purposes of this study, a 5-minute time interval was used as an objective where CTAS indicated "immediate" as the response time objective.

https://doi.org/10.1017/S1481803500006539 Published online by Cambridge University Press

sponse time objectives. CTAS emphasizes that the primary operational objective is the waiting time to see a physician. The CTAS time objectives provide useful standards for benchmarking, and examination of a department's fractile response rates (for registration-to nursing and registration-to-physician assessment times) provide an indication of the efficiency of assessing ED patients. Fractile response rates are also useful in measuring the effects of administrative interventions on ED processes and care delivery.

Our data show that, for the most critically ill or injured patients (Level I), nursing and physician response times were rapid, with little variability and that, overall, fractile response rate for nursing assessment were typically above 80%. At the time of this study, our practice was to have registration clerks see patients before the triage nurse. With this system, delays to triage were short for Levels I to II patients, but sometimes significant in Levels IV and V, perhaps reflecting situations where the triage nurse was pulled away to assist with patient care or when multiple patients arrived in a short time frame. Since the time of data collection, our ED has changed its processes so that triage now occurs before registration.

Tables 1 and 2 demonstrate that the mean time interval to physician assessment generally increased as triage acuity fell; however, fractile response rates were actually higher in Levels IV and V than in Level III, suggesting that physicians may, to some degree, violate triage prioritization and selectively seek non-urgent patients who require less assessment and treatment time — a de facto "fast-tracking" of low-acuity patients. The 32% fractile response rate in Level III patients is of concern; however, this behaviour may actually enhance overall efficiency, since operations research has shown that the average waiting time in a single-server queuing system can be minimized by first serving the customers with the shortest expected service time.[17,18]

In this study, non-urgent and critically ill patients spent the shortest time in the ED. Short throughput times for Levels IV and V patients are explained by lower investigation and consultation rates (Table 3). Investigation and consultation rates were similar in the top 3 triage categories; therefore, longer ED lengths of stay in Level III may reflect the fact that these patients often have vague clinical presentations (not clearly justifying admission or discharge) and require more prolonged observation, investigation and treatment in the ED.

Table 3. Investigations, consultations and admissions required for patients in each triage level

Triage level, (total no. of patients)	No. (and %) of patients			
	Lab tests	Imaging tests	Specialty consults	Admissions
I (9)	8 (89)	7 (78)	8 (89)	8 (89)
II (55)	37 (67)	41 (75)	40 (73)	36 (65)
III (297)	183 (62)	169 (57)	134 (45)	104 (35)
IV (327)	97 (30)	116 (35)	81 (24)	43 (13)
V (206)	18 (9)	60 (29)	17 (8)	11 (5)

The regression analysis allowed us to estimate the impact of service processes on ED LOS. The value of these data is not to show that diagnostic testing and specialty consultation prolong LOS, but rather to identify areas of particular concern. To illustrate, the 4.7-h delay associated with ultrasound imaging suggests an important process problem. In the study hospital, daytime ED patients requiring ultrasound are put "on-call" and "squeezed in" between regularly scheduled ultrasound studies, often resulting in very prolonged delays. ED patients arriving at night are often held until an ultrasound can be performed the next day; however, if this practice compromises patient safety or limits access to emergency care for other patients, then it is necessary to increase ultrasound accessibility — especially during off hours and weekends. The 2.1-h delay associated with laboratory testing suggests the need to

Table 4. Effect of specialty consultation on length of stay

Consultation service	LOS prolongation, h (SE)	*p*
Hematology*	9.6 (1.3)	<0.001
Gastroenterology*	4.3 (0.9)	<0.001
Internal medicine*	4.2 (0.7)	<0.001
Obstetrics/Gynecology	4.2 (3.2)	0.184
Psychiatry*	4.0 (0.8)	<0.001
Neurology*	3.5 (0.8)	<0.001
Nephrology*	3.1 (1.1)	0.005
Cardiology*	2.5 (0.8)	0.004
Pulmonary medicine*	2.5 (0.9)	0.004
Adult ICU	2.2 (1.9)	0.253
Neurosurgery*	1.7 (0.7)	0.014
Orthopedics	1.2 (0.9)	0.174
Plastic surgery	0.9 (0.8)	0.256
Urology	0.5 (1.4)	0.691
Infectious diseases	0.2 (1.8)	0.901
General surgery	0.1 (0.7)	0.865
Pediatrics	–0.1 (0.6)	0.858
ENT	–0.5 (1.6)	0.765
Pediatric ICU	–0.7 (2.0)	0.253
Cardiovascular surgery	–0.8 (1.8)	0.681

* Statistically significant impact on LOS
LOS = length of stay; SE = standard error; ICU = intensive care unit; ENT = ear, nose & throat

https://doi.org/10.1017/S1481803500006539 Published online by Cambridge University Press

scrutinize ED ordering processes, specimen acquisition, prioritization of ED testing, result reporting and, perhaps, the need for a dedicated ED lab to reduce LOS.[19]

In similar fashion, the multiple linear regression analysis enabled a limited measurement of the effects of consultation by specialty service, but did not identify reasons for the delays seen. Such reasons are likely to include a combination of patient characteristics, ED physician activities, consultation processes and specialty service practices.

An R^2 of 0.384 for the regression model reflects mediocre predictive ability and indicates that other factors not examined explain much of the variability in LOS. Further research is required to determine the impact of predictors like socioeconomic status, comorbidity, residency and referral, ED staffing levels,[20] hospital bed capacity and occupancy rates, and hospital policies for housing admitted patients.[21]

Limitations and future research

A major limitation of this study is that data were gathered manually from handwritten patient charts and that the study period was limited to one week, precluding analysis of seasonal variation. As with any chart review, deficits in documentation prevented the accurate capture of data elements for several patient care records. The implementation of better ED information systems will allow for more accurate, reliable and prolonged data collection to aid in decision-making. In the future, ED administrators and researchers should be able to perform time studies with relative ease and on a frequent basis.

Another limitation of this investigation is the failure to delineate causal relationships between predictor variables and LOS. ED processes are interdependent and subject to external influences; therefore, improvement in one area may not shorten LOS, and meaningful change may involve adjusting a combination of many factors — the identification of which may be difficult.

A final concern is that the generalizability of our findings may be limited because sociodemographic factors, ED work processes, ED management structures, presence of learners, EMS characteristics, availability of specialty consultation and inpatient services all vary across sites and would be expected to influence ED LOS.

Other research tools such as qualitative methodologies may help clarify causal factors for prolonged LOS. Computer simulation has been used with success in improving ED operations,[22,23] and this technology may be well suited to examining the factors that influence ED efficiency and overcrowding. The concept of testing system changes and administrative interventions before actually implementing them is an enticing one.

Conclusion

Time studies provide useful process data to identify system inefficiencies and for benchmarking purposes. LOS profiles, stratified by triage level, will be key ED management tools and will facilitate collaborative efforts to improve ED patient flow. Future information systems and statistical modeling techniques will make it easier for administrators and researchers to better analyze ED processes and outcomes.

Competing interests: None declared.

Ackowledgements: We thank Drs. J.D. Jobson and Duncan Saunders for their assistance in reviewing previous versions of this paper.

Grant support: Supported by the Division of Emergency Medicine, Faculty of Medicine & Dentistry, University of Alberta.

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