The Effect of Low-Complexity Patients on Emergency Department Waiting Times

Michael J. Schull, MD, MSc, FRCPC
Alex Kiss, PhD
John-Paul Szalai, PhD†

From the Institute for Clinical Evaluative Sciences, Toronto, Ontario, Canada (Schull, Kiss, Szalai); the Clinical Epidemiology Unit (Schull, Kiss, Szalai) and Department of Emergency Services (Schull), Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada; and the Department of Medicine, University of Toronto, Toronto, Ontario, Canada (Schull).
†Deceased.

Study objective: The extent to which patients presenting to emergency departments (EDs) with minor conditions contribute to delays and crowding is controversial. To test this question, we study the effect of low-complexity ED patients on the waiting times of other patients.

Methods: We obtained administrative records on all ED visits to Ontario hospitals from April 2002 to March 2003. For each ED, we determined the association between the number of new low-complexity patients (defined as ambulatory arrival, low-acuity triage level, and discharged) presenting in each 8-hour interval and the mean ED length of stay and time to first physician contact for medium- and high-complexity patients. Covariates were the number of new high- and medium-complexity patients, mean patient age, sex distribution, hospital teaching status, work shift, weekday/weekend, and total patient-hours. Autoregression modeling was used given correlation in the data.

Results: One thousand ninety-five consecutive 8-hour intervals at 110 EDs were analyzed; 4.1 million patient visits occurred, 50.8% of patients were women, and mean age was 38.4 years. Low-, medium-, and high-complexity patients represented 50.9%, 37.1%, and 12% of all patients, respectively. Mean (median) ED length of stay was 6.3 (4.7), 3.9 (2.8), and 2.2 (1.6) hours for high-, medium-, and low-complexity patients, respectively, and mean (median) time to first physician contact was 1.1 (0.7), 1.3 (0.9), and 1.1 (0.8) hours. In adjusted analyses, every 10 low-complexity patients arriving per 8 hours was associated with a 5.4-minute (95% confidence interval [CI] 4.2 to 6.0 minutes) increase in mean length of stay and a 2.1-minute (95% CI 1.8 to 2.4 minutes) increase in mean time to first physician contact for medium- and high-complexity patients. Results were similar regardless of ED volume and teaching status.

Conclusion: Low-complexity ED patients are associated with a negligible increase in ED length of stay and time to first physician contact for other ED patients. Reducing the number of low-complexity ED patients is unlikely to reduce waiting times for other patients or lessen crowding. [Ann Emerg Med. 2007;49:257-264.]

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INTRODUCTION

Background

In 2002, more than 110 million emergency department (ED) visits occurred in the United States, a 23% increase since 1992.[1] This increase in utilization has coincided with a period of worsened ED crowding, with surveys reporting the problem in almost every state[2-5] on almost every day.[3,5] Several studies have documented substantial utilization of EDs by low-acuity patients,[6-8] but no study has found a convincing association between low-acuity utilization and ED crowding. Nonetheless, some observers have concluded that crowding might be alleviated by diverting low-acuity patients away from EDs.[9-14]

Importance

Studies of the causes of crowding have found the problem to be associated primarily with higher-acuity patients, especially those who require hospital admission,[15,16] and we are unaware of published evidence suggesting that low-acuity patients directly contribute to crowding. However, treating any ED

Editor's Capsule Summary

What is already known on this topic

Previous studies have shown that use of the emergency department (ED) by low-acuity patients is common. However, the degree to which this phenomenon contributes to ED crowding is unknown.

What question this study addressed

The degree to which low-complexity patient visits affect total ED length of stay and the time to be treated by a physician for higher-complexity ED patients.

What this study adds to our knowledge

In this large study of more than 4 million patient visits at 110 EDs, the authors found that for each low-complexity patient who arrives in the ED, the remaining patients experience an increased ED length of stay of 32 seconds and an increased time to be treated by a physician of 13 seconds.

How this might change clinical practice

In this study, low-complexity patients had a relatively small effect on the timeliness of care for more complex ED patients, suggesting that attempts to divert low-complexity ED patients to alternative sites for clinical care are unlikely to substantially improve either ED waiting times or ED crowding.

patient, even ones with minor complaints and injuries, requires a treatment space and staff time, both of which could otherwise be devoted to the treatment of other patients. Thus, it has been theorized that treating low-acuity patients distracts ED personnel from the treatment of more acutely ill patients, leading to longer delays for those patients and hence to worsened crowding.[10,11,17]

Goals of This Investigation

The goal of this study is to test whether low-acuity ED patients delay the treatment of the higher-acuity patients. Our objectives were to determine whether the volume of ED patients with minor conditions is associated with, first, the length of stay of other ED patients and, second, the timeliness of treatment of other ED patients defined as the time to first physician assessment. Our hypothesis was that the volume of patients with minor conditions is not associated with delays for other patients. These results have policy relevance because measures designed to divert minor patients away from EDs are unlikely to reduce crowding unless they affect the treatment given to other patients.

MATERIALS AND METHODS

Study Design and Setting

Previous studies on ED crowding suggested that causes could be divided into input, throughput, and output domains.[18] Input factors include patient volume and case mix (reflected by age and sex, acuity of illness, mode of arrival in the ED), throughput factors include those influencing efficiency of assessment and treatment, and output factors include admission rates and the efficiency of disposition. Both throughput and output factors are reflected in total ED length of stay. Other factors that affect crowding include static ED factors such as teaching hospital status and size of ED, dynamic ED factors such as sudden surges in patient presentations or inpatient bed availability, and contextual factors such as time of day and day of week. Our study tested the association between the volume of ED patients with minor conditions (an input factor) and the length of stay of other ED patients.

The design was a retrospective study of patients presenting for treatment in an Ontario ED from April 1, 2002, to March 31, 2003, in Ontario, Canada's largest province, with a population of 12 million people.

Selection of Participants and Data Collection and Processing

Patient records were identified from the National Ambulatory Care Reporting System, an administrative database that contains abstracts of all ED visits in Ontario. Records were excluded if the health insurance number or postal code was invalid (eg, non-Ontario citizens) to ensure a sample representative of the Ontario population. The Canadian Triage and Acuity Scale has been adopted by the Ontario Ministry of Health as the standard triage scale for all EDs in the province, ensuring a comparable measure of patient acuity across different hospitals. The scale has 5 levels (resuscitation=1; emergency=2; urgent=3; less urgent=4; nonurgent=5), with standard definitions and training and implementation guidelines.[19,20] National Ambulatory Care Reporting System abstracts are completed by trained hospital medical records coders at each hospital with an ED. The government mandates that hospitals submit data on all ED visits to the Canadian Institute for Health Information, which maintains the database and ensures data quality.[21]

Methods of Measurement

We defined complexity according to the intensity of care provided to patients during their ED stay, reflected by the triage score, their mode of arrival, and their disposition. Triage acuity score alone is a poor predictor of complexity at the patient level[11] but does predict resource utilization.[22] Other factors such as mode of arrival, the need for hospital admission, and the time and resources required to treat a patient also affect complexity.[23] To increase specificity, we defined low-complexity patients according to 3 factors: a Canadian Triage Acuity Score of less urgent (4) or nonurgent (5),[24] ED arrival not by ambulance, and discharged home. High-complexity patients were defined to be those who were admitted to the hospital,

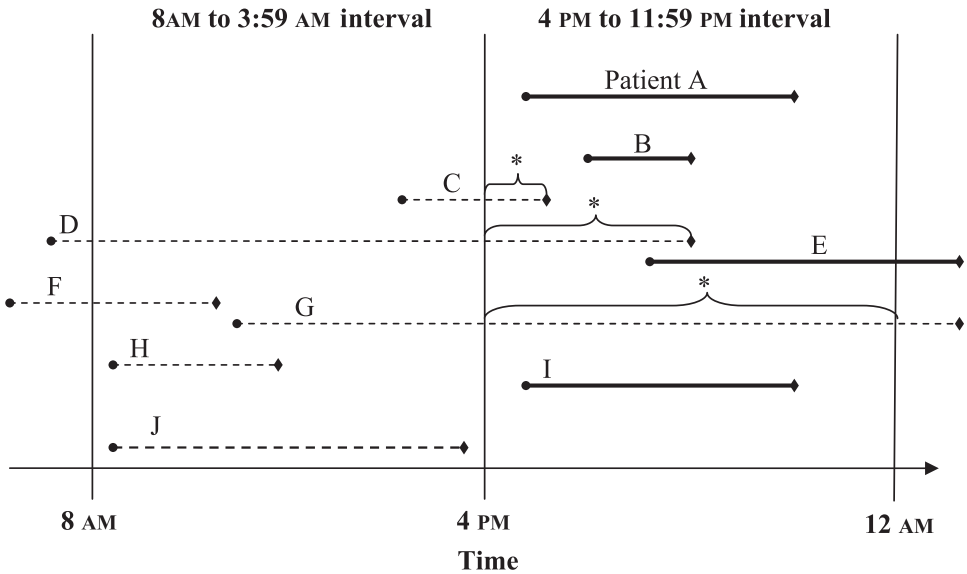

Figure 1. Graphic representation of patient length-of-stay (LOS) calculations for 1 hypothetical interval in 1 ED. Each line represents 1 ED patient from time of registration to disposition; solid lines for new patients registered in the interval; dotted lines for patients who registered in a previous interval. Mean ED LOS for the 4 PM to 11:59 PM interval was calculated as the average total LOS of patients A, B, E and I, stratified by patient complexity. The number of patient-hours spent in the interval by patients who registered in a previous interval was calculated as the sum of the portion of the total LOS spent by patients C, D, and G during the interval (indicated by an asterisk and horizontal parenthesis), stratified by patient complexity. Patients F, H, and J would not contribute to the analysis for the 4 PM to 11:59 PM interval. In the figure, all patients had the same complexity to simplify the representation.

given that these patients generally require more intensive assessment and treatment in the ED. All other patients were defined as medium complexity. Medium- and high-complexity patients together constituted non–low-complexity patients.

Outcome Measures

Our primary outcome was mean ED length of stay per interval for non–low-complexity patients, defined as the difference between the time of patient registration and patient disposition. If a patient's length of stay extended into a subsequent interval, the entire length of stay was assigned to the interval in which the patient registered. Our secondary outcome, time to first physician contact per interval for non–low-complexity patients, was calculated as the difference between time of patient registration and the time the patient was first treated by a physician (including residents in teaching hospitals).

All variables and outcomes were calculated for each interval at each ED. We counted new patients (ie, those registering in each interval), separately by complexity level. The main predictor was the number of new low-complexity patients presenting per interval. We accounted for the effect of patients who had registered in a previous interval but who were still registered in the ED in a subsequent one (and therefore still contributing to congestion and workload) by calculating the time each such patient was present in the ED in a subsequent interval. For each interval, we totaled the patient-hours for low-, medium-, and high-complexity patients (Figure 1). We also controlled for the following covariates in each interval: average new patient age, proportion of women among new patients, teaching hospital (yes/no), work shift (day, evening, night), and day of week (weekend/weekday).

Primary Data Analysis

The observations in this study were consecutive intervals within each ED and are therefore likely to be autocorrelated or related to one another (ie, the length of stay in interval 1 is likely to be associated with that of interval 2, etc). As a result, the error terms are not independent and a core assumption of linear regression analysis is violated, making usual regression methods inappropriate for their analysis. Time-series analysis allows for autocorrelation of observations when the association between predictor variables and outcome is determined.[25] An autoregressive model, one in which the current time-series value is related to the actual time-series values from previous time periods, was chosen as the appropriate modeling technique. A regression coefficient (and 95% confidence interval [CI]) was estimated for each predictor variable in univariate and multivariate models, representing the change in minutes in the dependent or outcome variable per unit change in the variable. Goodness of fit and additional model details are provided in Appendix E1 (available online at

Table 1. Clinical and demographic characteristics of ED patients (n=4,174,029).

Variable	Value	Percentage
Age, y	Mean (SD)	38.4 (24.5)
Sex	Female	50.8
Mode of arrival	Ambulance	12.6
	Self-transport	87.4
Triage acuity score*	Resuscitation	0.4
	Emergent	7.5
	Urgent	35.5
	Less urgent	42.5
	Nonurgent	14.1
Patient complexity	High	12.0
	Medium	37.1
	Low	50.9

*Based on the Canadian Triage and Acuity Scale.

http://www.annemergmed.com). SAS software (version 9.0, Unix; SAS Institute, Inc., Cary, NC) was used for all analyses.

We analyzed the 2 dependent variables, ED length of stay and time to first physician contact, as time series summarized during 1,095 consecutive 8-hour intervals (365 days, with 3 work shifts per day) for each ED. This method has been used previously to study the effect of various factors on ED outcomes.[16,26,27] We excluded from analyses EDs with annual volumes below the 25th percentile for the province (13,015 visits per year) and specialized pediatric EDs to remove sites that have utilization patterns that are distinct from that of higher volume centers.[23]

Sensitivity Analyses

We carried out 2 sensitivity analyses. We stratified EDs into moderate- (25th to 85th percentile) and high-volume (>85th percentile) groups to determine whether the results differed according to ED volume. We also altered our definition of low-complexity patient to include only Canadian Triage and Acuity Scale level 5 patients who arrived ambulatory and were not admitted to determine whether it affected our results.
The study was approved by the research ethics board of the Sunnybrook Health Sciences Center.

RESULTS

There were a total 4,771,092 visits to 173 EDs in the province, 86.1% of them to nonteaching hospitals. Sixty-three low-volume or specialized pediatric EDs were excluded, leaving 110 EDs (94 community and 16 teaching hospitals). Table 1 provides the demographic and presenting clinical data for the patients. A total of 760 records were excluded because of missing or invalid sex, age, length of stay, or triage data.
Other records with missing or invalid health care numbers (n=165,310) or postal codes (n=13,204) were also excluded, leaving a total of 4,174,029 visits for the main analysis. Time to first physician contact analyses was restricted to the 3,660,766 records with time to first physician contact documented (87.7% of the total).

Table 2 provides data on patient length of stay and time to first physician contact overall and by hospital type, time of day, and patient complexity. Median length of stay was substantially longer in teaching than in community hospitals (3.3 versus 2.1 hours), and increased steadily with patient complexity. Median time to first physician contact was greatest for medium-complexity patients and lowest for high-complexity patients.

Overall, there was a median of 16 new low-complexity, 9 new medium-complexity, and 2 new high-complexity patients in each interval. Low-complexity patients were almost twice as frequent in community hospitals as other patient types, whereas in teaching hospitals, low- and medium-complexity patients were of equal frequency (Figure 2). We calculated total patient-hours in each interval among patients who had registered in a previous interval; low-, medium-, and high-complexity patients spent a median of 8.7, 25.3, and 20.1 patient-hours per interval in teaching hospitals versus 3.9, 8.0, and 3.8 patient-hours per interval in community hospitals, respectively. In both community and teaching hospitals, medium-complexity patients who had registered in previous intervals contributed the largest proportion of patient-hours.

Table 3 provides the results of the autoregression model of mean ED length of stay for non–low-complexity patients. The large sample size of the study (110 EDs, each with 1,095 work shifts) results in a high degree of statistical power to detect very small effect sizes and highly significant *P* values. Each additional new low-complexity patient per interval was associated with an increase in mean ED length of stay for non–low-complexity patients of 0.54 minutes (95% CI 0.42 to 60 minutes), or 5.4 minutes (95% CI 4.2 to 6.0 minutes) for every 10 new low-complexity patients. Older mean patient age, teaching hospital status, weekdays, and the day and night shifts were all associated with increased mean length of stay for non–low-complexity patients; sex distribution had no detectable effect.

Table 4 provides the results for the time to first physician contact analysis. In adjusted models, each new low-complexity patient presenting per interval was associated with an increase in mean time to first physician contact for non–low-complexity patients of 0.21 minutes (95% CI 0.18 to 0.24 minutes), or 2.1 minutes (95% CI 1.8 to 2.4 minutes) per 10 new low-complexity patients. These results allow us to generate meaningful estimates of the effect of low-complexity patients in a typical work shift. Multiplying the median number of new low-complexity ED patients presenting each interval (16) by the appropriate effect suggests that low-complexity patients would be associated with an 8.6-minute (95% CI 6.7 to 9.6 minutes) and 3.4- minute (95% CI 2.9 to 3.8 minutes) increase in mean ED length of stay and time to first physician contact, respectively, for non–low-complexity patients in a typical 8-hour interval.

Patient–hours contributed by patients who registered in a prior interval were also associated with increased mean ED

Table 2. ED length of stay and time to first physician contact.

	ED Length of Stay, h*			Time to First Physician Contact, h†		
Patient Group	**Mean (SD)**	**Median**	**IQR‡**	**Mean (SD)**	**Median**	**IQR‡**
All patients	3.4 (4.3)	2.2	1.1–4.0	1.2 (1.2)	0.8	0.3–1.6
By hospital type						
Teaching	4.7 (5.1)	3.3	1.8–5.7	1.4 (1.3)	1.0	0.5–1.8
Community	3.1 (4.1)	2.1	1.1–3.7	1.1 (1.2)	0.7	0.3–1.6
By work shift						
Day	3.4 (4.2)	2.2	1.1–4.1	1.1 (1.2)	0.8	0.3–1.5
Evening	3.2 (4.1)	2.1	1.1–3.7	1.2 (1.2)	0.9	0.4–1.7
Night	3.8 (4.8)	2.3	1.1–4.6	1.1 (1.2)	0.7	0.3–1.5
By patient complexity						
High	6.3 (5.5)	4.7	2.8–7.8	1.1 (1.3)	0.7	0.3–1.5
Medium/high combined	4.5 (5.2)	3.2	1.7–5.5	1.2 (1.3)	0.8	0.4–1.7
Medium	3.9 (4.9)	2.8	1.5–4.7	1.3 (1.3)	0.9	0.4–1.7
Low	2.2 (2.7)	1.6	0.9–2.7	1.1 (1.1)	0.8	0.3–1.5

IQR, Interquartile range.
*Based on n=4,174,029 ED visits.
†Based on n=3,660,766 ED visits with time to treatment by physician documented.
‡IQR is the 25th and 75th percentiles.

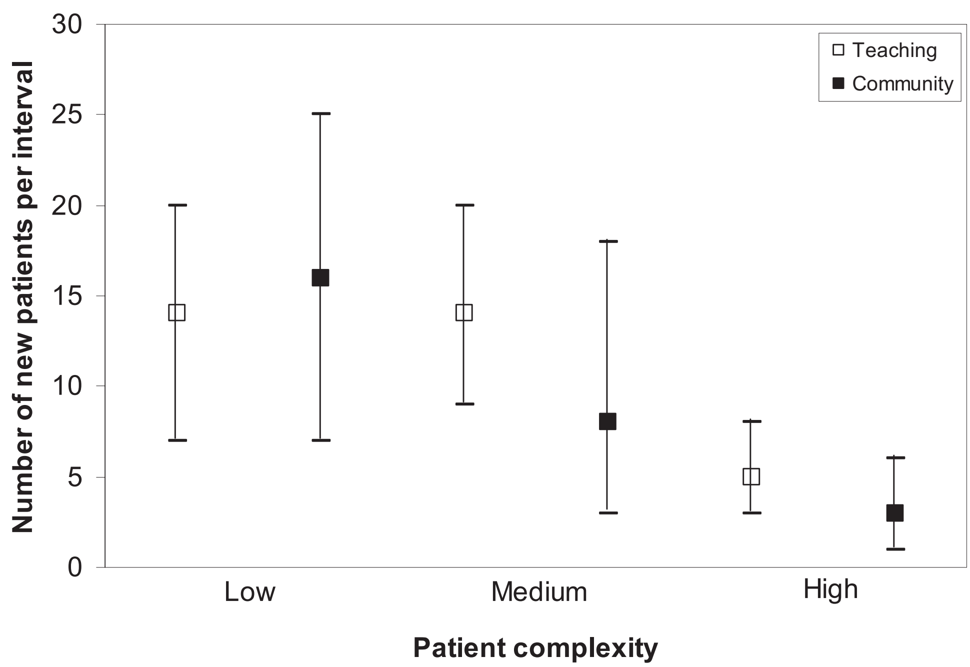

Figure 2. Median (and 25th and 75th percentile) number of new patients registering per interval, by hospital type and patient complexity.

length of stay in subsequent intervals; the effect was almost 10-fold greater for a high-complexity patient-hour than it was for a low-complexity patient-hour. Estimates for the effect of new medium- and high-complexity patients on ED length of stay and time to first physician contact for non–low-complexity patients should be interpreted cautiously because the individual lengths of stay of those patients were used to calculate the mean ED length of stay for the interval, which means that the number of new medium- and high-complexity patients will directly affect the calculation of the main outcome, leading to potential circularity (or endogeneity) in the modeling structure. This does not affect the interpretation of the effect of new low-complexity patients, however.

We stratified both the ED length of stay and time to first physician contact analyses by ED volume, analyzing moderate-volume EDs (25th to 85th percentile) separately from high-volume ones (>85th percentile); the results were similar in both volume groups. We also repeated the analysis with a modified definition of low-complexity patients (restricted to Canadian Triage and Acuity Scale level 5

Table 3. Multivariable analysis of predictors of ED length of stay for medium- and high-complexity patients.

Variable	Absolute Change (min) in Mean Length of Stay for Medium- and High-Complexity Patients	95% CI
Number of new ED patients per interval		
Low complexity	0.5	0.4–0.6
Medium complexity	1.0	0.8–1.1
High complexity	7.2	7.2–7.8
New patient demographics		
Mean age	1.9	1.7–2.0
Proportion female	4.3	−0.8–9.6
Patients registered in previous intervals (patient-hours)		
Low complexity	0.08	0.02–0.1
Medium complexity	0.3	0.2–0.4
High complexity	0.6	0.5–0.7
Context		
Hospital type, teaching (vs nonteaching)	75	61.8–88.8
Day of week, weekend (vs weekday)	−7.8	−9.6 – −6.0
Day (vs evening)	11.4	8.4–15
Night (vs evening)	49.8	45.6–54.0

Table 4. Multivariable analysis of predictors of time to first physician contact for medium- and high-complexity ED patients.

Variable	Absolute Change (min) in Mean Time to First Physician Contact for Medium- and High-Complexity Patients	95% CI
Number of new ED patients per interval		
Low complexity	0.2	0.2-0.2
Medium complexity	1.0	0.9-1.0
High complexity	1.5	1.4-1.6
New patient demographics		
Mean age	0.1	0.1-0.2
Proportion female	1.3	−0.08-2.6
Patients registered in previous intervals (patient-hours)		
Low complexity	0.1	0.1-0.2
Medium complexity	0.2	0.2-0.2
High complexity	0.3	0.2-0.3
Context		
Hospital type, teaching (vs nonteaching)	−6.6	−10.8-−1.7
Day of week, weekend (vs weekday)	−1.0	−1.6-−0.5
Day (vs evening)	174	114-240
Night (vs evening)	9	7.8-10.2

patients only); the results were again similar to those of the main analyses.

LIMITATIONS

Our study is limited by several factors. There is no standard definition of a low-complexity patient[28,29]; hence, we chose a definition based on features at presentation and disposition, which was intended to result in a more specific definition, not one that could be used prospectively to identify such patients. By design, our analysis considered only the effect of changes to the number of low-complexity patients presenting to EDs, given current ED staffing and resource configurations. Permanent and substantial reductions in the number of low-complexity ED patients might allow for the reallocation of staff or treatment spaces to the care of sicker patients. Our study could not determine how changes in the number of low-complexity patients might affect their treatment and length of stay. We relied on administrative data that are not collected primarily for research purposes. The data elements we used for our primary analysis were complete; however, there were some missing data for time of first physician contact. We compared patients with and without time of first physician contact documented and found no substantive differences. We did not have information on the number of physicians on duty (which could influence the effect of patient volume) or the time of patient arrival in the ED (which would be the ideal starting point for length of stay). Using administrative data strengthened our results by enabling the inclusion of a large number of hospitals, both community and teaching, increasing their generalizability.

DISCUSSION

Our results suggest that the number of patients presenting to EDs with minor illnesses and injuries has a negligible effect on the overall waiting times of other ED patients. In a typical 8-hour interval, a median of 16 new low-complexity ED patients presented for treatment, which is associated with an increase in mean ED length of stay of 8.6 minutes for non–low-complexity patients (representing a 4.2% increase) and a 3.4-minute increase in mean time to first physician contact (representing a 4.8% increase). These differences are statistically significant, given our large sample size, but are not clinically important. Our results suggest that low-complexity patients have little impact on the timeliness of care for other ED patients.

Not all patients who met our low-complexity definition would have been candidates to be diverted away from EDs to be treated elsewhere. Nonetheless, because patients who could potentially be diverted would likely be the least complex of the low-complexity group, our results suggest that attempts to divert such patients away from EDs are unlikely to produce meaningful improvements in waiting times for sicker patients.

The utilization of EDs by patients with low-complexity conditions has been studied with respect to frequency, appropriateness, cost, and access to alternatives.[8,10,28,30-33] More recently, rising ED utilization and worsened crowding[8,10] have led to studies of the safety of diverting low-complexity patients elsewhere for treatment; however, no study has assessed the benefits of doing so. Dedicated fast-track or rapid assessment units have become more common in EDs in the United States and elsewhere. One small study examined the effect of diverting low acuity to a rapid assessment unit when they required only brief assessments and simple interventions and had a disposition that was apparent at triage.[17] This single-center study found that ED length of stay and time to treatment by a physician improved for low-acuity patients, including those diverted to the rapid assessment unit, but did not change for sicker patients who remained in the ED. Our results similarly suggest that reducing the number of low-complexity patients in EDs would do little to improve ED performance for sicker patients and hence do little to reduce crowding. The likely reasons are that most low-complexity patients are not placed in the treatment spaces used for sicker patients,[11] the resources they require are generally simple and readily available (hence, their use does not affect sicker patients), and staff are either dedicated to their treatment (eg, fast-track units) or allocate time to these patients in lower priority than they do for sicker patients.

Our study does not address the question of whether the ED is the best alternative for the treatment of low-complexity patients from the patient's point of view. Better access to alternatives such as urgent care clinics or family physician offices might be preferable to these patients and could result in better continuity of care and less waiting for them. However, one study found that low-complexity ED patients had better access to and were heavier users of primary care services than other patients,[34] were frequently dissatisfied with their usual source of care,[35] and were no less likely to have medical insurance than the general population.[36] It is therefore not surprising that in one study, almost half of all ED patients deemed safe to be diverted to a guaranteed next-day clinic appointment refused the offer, preferring to wait to be treated in the ED.[10]

Low-complexity patients represent half of all patients treated in community and teaching hospital EDs in Ontario, but they do not have a substantial impact on the efficiency or timeliness of care given to other, more acutely ill, ED patients. The cost of diverting these patients away from EDs is unknown,[8,28] the safety is unproven,[10,32,33] and our results suggest that doing so would fail to reduce crowding in EDs.

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Address for correspondence: Michael J. Schull, MD, MSc, FRCPC, G-106, Institute for Clinical Evaluative Sciences, 2075 Bayview Ave, Toronto, Ontario, Canada, M4N 3M5; 416-480-6100 ext3793, fax 416-480-6048; E-mail mjs@ices.on.ca.

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APPENDIX E1.

An autoregressive model was chosen as the appropriate model for analysis purposes. An autoregressive model is one in which the current time-series value is related to the actual time-series values from previous periods. These models are a type of autoregression integrated moving average (ARIMA) model. Durbin Watson statistics were calculated to test for autocorrelation. An order of 4 was chosen as a value larger than the expected order of variation across the 3 shifts. This statistic was found to be highly significant (Durbin Watson=1.77, $P<.0001$) indicating the presences of positive autocorrelation. An autoregressive model with 41 lags was fit to the data. This number of lags encompassed a 2-week period, with insignificant autoregressive parameters removed from the final model. The goodness of fit of the model is provided by the root mean square error term, as well as the estimates of the autoregressive parameters at each lag retained in the model. The root mean square error value of 0.64, as well as the significant t values for the various lags, indicates that the autoregressive model provided a good fit to the data.

Mean ED length of stay and time to first physician contact showed no major underlying seasonality, as is shown in Figure E1.

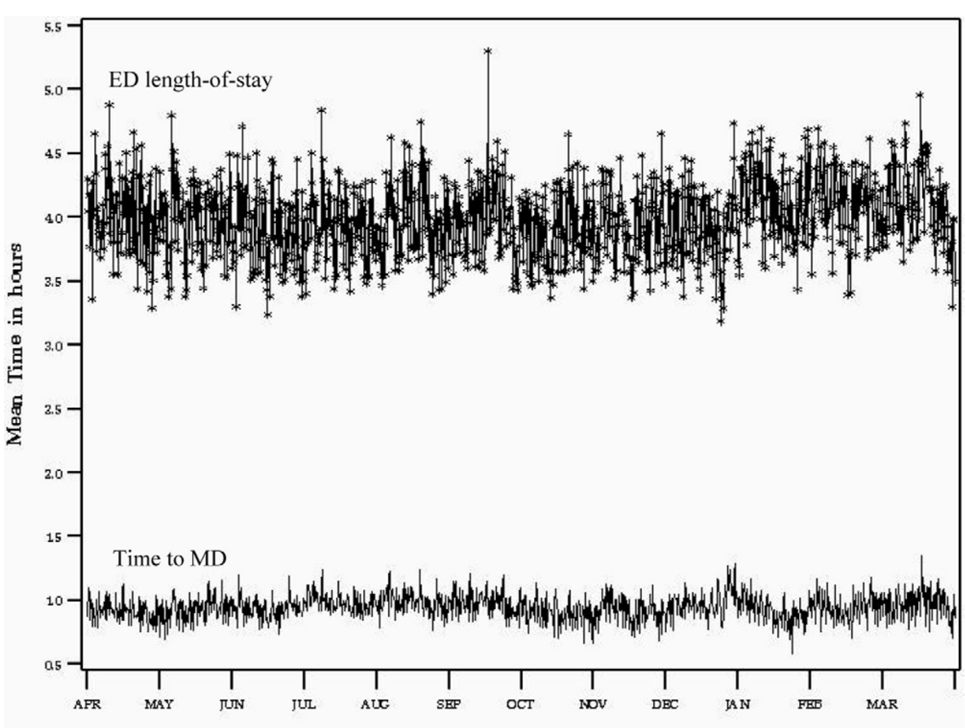

Figure E1. Time series of mean ED length of stay and time to first physician contact for medium- and high-complexity patients combined during consecutive 8-h intervals. The data were summarized across all 110 study hospitals for display purposes only, but a separate time series was created for each hospital.