Emergency department boarding: a descriptive analysis and measurement of impact on outcomes

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CLINICIAN'S CAPSULE

What is known about the topic?
Bed boarding is one of the major contributors to emergency department overcrowding.
What did this study ask?
What are the characteristics of patients with prolonged boarding times, and what are the impacts on patient-oriented outcomes?
What did this study find?
Patients who were older, sicker, and had isolation and telemetry requirements experienced longer boarding times, and longer inpatient length of stay even after correcting for confounders.
Why does this study matter to clinicians?
Organization-wide interventions to improve efficiency and flow are required to mitigate the burden of bed boarding.

ABSTRACT

Objectives: Delays in transfer of admitted patients boarded in the emergency department (ED) to an inpatient bed is a major driver of ED overcrowding. We sought to identify explanatory factors behind ED boarding as well as the impact of boarding on total inpatient length of stay (IP LOS) and inpatient mortality.
Methods: We conducted a retrospective single-centre observational study during the period between January 1 and December 31, 2015 at a very high volume community hospital. All patients admitted from the ED to Medicine, Pediatrics, Surgery, and Critical Care were identified. The mean ED LOS and boarding time as well as patient-specific and institutional factors that were independently associated with prolonged ED LOS (≥24 hours) and prolonged boarding time (≥12 hours) were identified. Mean inpatient length of stay (IP LOS) and the odds of inpatient mortality were calculated for those patients with prolonged ED wait times.
Results: There were 13,872 unique admissions during the study period. Patients admitted to the Medicine service

exhibited significantly higher ED wait times than other services. Within Medicine patients, there was a statistically significant greater odds of prolonged ED wait times for patients who were older, had a greater comorbidity burden, and required more specialized inpatient care. Medicine patients with prolonged boarding times also experienced a mean of 0.9 days longer IP LOS even after adjusting for confounders.
Conclusion: Within our cohort, older, sicker patients and those patients requiring more resource-intensive inpatient care had the longest ED wait times. These prolonged wait times are associated with significantly increased IP LOS.

RÉSUMÉ

Objectif: Les retards de mutation des patients du service des urgences (SU) à l'étage est un facteur important d'engorgement. L'étude visait donc à cerner des facteurs sous-jacents aux délais d'attente au SU avant l'hospitalisation et à évaluer l'incidence de ces délais sur la durée totale du séjour à l'hôpital et sur la mortalité chez les malades hospitalisés.
Méthode: Il s'agit d'une étude d'observation, rétrospective et unicentrique, menée dans un hôpital communautaire recevant un nombre élevé de malades, entre le 1er janvier et le 31 décembre 2015. Ont été relevés tous les dossiers des patients hospitalisés, depuis le SU, dans les services de médecine, de pédiatrie, de chirurgie et de soins intensifs. La durée moyenne de séjour au SU (DSSU) et le temps moyen d'attente avant l'hospitalisation ainsi que des facteurs propres aux patients et à l'établissement associés de manière indépendante à une DSSU prolongée (≥24 heures) et à un délai d'attente prolongé avant l'hospitalisation (≥12 heures) ont été notés. Nous avons calculé, pour les patients ayant connu un délai d'attente prolongé au SU, la durée moyenne de séjour à l'hôpital et les cotes de mortalité chez les patients hospitalisés.
Résultats: Il y a eu 13 872 hospitalisations en un seul séjour durant la période à l'étude. Les patients admis au service de médecine ont connu des délais d'attente au SU

significativement plus élevés que ceux admis dans d'autres services. Parmi les patients hospitalisés au service de médecine, les cotes de délai d'attente prolongé au SU étaient significativement plus élevées pour les patients âgés, pour ceux souffrant de maladies concomitantes et pour ceux ayant besoin de soins spécialisés à l'hôpital. En outre, les patients admis au service de médecine ayant connu un long délai d'attente avant l'hospitalisation ont également connu un séjour à l'hôpital plus long de 0,9 jour en moyenne, et ce, même après rajustement des facteurs parasites.

Conclusion: Les résultats de l'étude ont démontré que, au sein de la cohorte étudiée, les patients âgés, les patients les plus malades et ceux dont l'état nécessitait beaucoup de ressources à l'hôpital ont également connu les délais d'attente les plus longs au SU. D'ailleurs, ces derniers délais ont été associés à une augmentation significative de la durée de séjour à l'hôpital.

INTRODUCTION

Over the past several decades, emergency department (ED) overcrowding has become a chronic, worsening problem in Canada and internationally. This overcrowding leads to a detrimental effect on patient care, ED efficiency, and patient and provider satisfaction.[1,2] Previous studies have shown a link between increased ED overcrowding and worse clinical outcomes, increased risk of in-hospital mortality, higher costs, and longer times to treatment.[3-8]

The cause of ED overcrowding is thought to be a combination of input, throughput, and output factors.[3,4,9,10] *Input* factors encompass causes of patient inflow to the ED (e.g., non-urgent visits due to the lack of access to primary care, "frequent flyer" patients). *Throughput* factors are capacity-related issues or operational bottlenecks and inefficiencies within the ED (e.g., inadequate staffing or physical space). *Output* factors reflect bottlenecks or inefficiencies in other parts of the institution – or within the local healthcare and social system as a whole – that have upstream effects on ED operations and flow (such as bed availability within inpatient units).[4,8]

Within Ontario, roughly 10% of patients who present to the ED are admitted to the hospital. Recent data show a median time to inpatient bed for these patients of 3.7 hours and a 90th percentile time to inpatient bed of 23.3 hours (Figure 1).[11,12] Recently, there has been a great deal of interest within the public, the media, and the government on the issue of delays in the transfer of admitted patients out of the ED – otherwise known as *bed boarding*. Bed boarding is felt to negatively impact ED flow and efficiency, lead to adverse effects for the patients themselves, and is believed to be one of the chief drivers of ED overcrowding.[2,4,8,13]

The impact of ED wait times for admitted patients on clinically oriented outcomes has been explored in multiple studies.[3-6,14-16] However, there are few Canadian studies that have explored the characteristics, drivers, and patient-oriented outcomes associated with ED wait times for those patients admitted to the hospital but boarded in the ED while awaiting a bed on the inpatient unit.[5] We seek to explore the nature and impact of prolonged ED wait times through a series of exploratory and regression analyses. Our study objectives are to 1) describe the patient-specific characteristics of boarded patients stratified by inpatient service, 2) identify the patient population with the most prolonged ED wait times, 3) within this patient population identify patient-specific characteristics associated with prolonged wait times, and 4) determine any association between prolonged ED wait times and two clinically relevant patient-oriented outcomes of a) inpatient length of stay (IP LOS) and b) inpatient mortality. Within our study, we use two definitions of ED wait times: 1) total ED length of stay (ED LOS) and 2) total boarding time (or time to bed [TTB]) after a decision to admit.

METHODS

Study site

Our centre is a very high volume community hospital, with >135,000 ED visits per year and a 13% admission rate for the 2015-2016 fiscal year. Ontario Ministry of Health data show that, for the 2015-2016 fiscal year, roughly 3.5% of our total ED patient population had ED LOS > 24 hours, whereas roughly 24.9% of our admitted patient population had ED LOS > 24 hours.[11] Within the subgroup of admitted patients, the median boarding time (i.e., TTB) was 5.2 hours, whereas the 90th percentile boarding time was 30.7 hours.[11]

Study design and data collection

We conducted a retrospective single-centre observational study of patients admitted to a hospital inpatient

unit through the ED during the period between January 1, 2015 and December 31, 2015. Patient data were accessed from electronic patient and administrative hospital records through our Decision Support unit. Collected variables included patient demographics and clinical characteristics (including telemetry requirements, isolation status, and comorbidity level),[17-19] ED wait times, IP LOS, and inpatient mortality. The comorbidity level (ranging from level 0 to level 4) is an index developed by the Canadian Institute of Health Information (CIHI) to measure a patient's resource consumption during his or her hospitalization relative to that of other patients within the same major clinical category. Patients with higher comorbidity levels have higher relative resource consumption:

Level 0: the coded comorbidities on the episodes have no or <1.25 times impact on resource consumption.

Level 1: the coded comorbidities on the episodes have 1.25 up to 1.5 times more resource consumption.

Level 2: the coded comorbidities on the episodes have 1.5 up to 2 times more resource consumption.

Level 3: the coded comorbidities on the episodes have 2 up to 3 times more resource consumption.

Level 4: the coded comorbidities on the episodes have 3 or more times more resource consumption.

ED wait times comprised total ED LOS, calculated in hours from the time of triage to the time when the patient physically left the ED, and TTB, calculated in hours from the time of the decision to admit to the time that the patient physically left the ED for an inpatient bed (see Figure 1). Our study population included all patients admitted to the following admitting services: medicine, surgery, pediatrics, and critical care. The admitting service was determined by the unit of admission, as well as the admitting service as described by the coded hospital data. Patients who were admitted to an inpatient unit from the ED but were ultimately discharged from the ED (without having been physically transferred to an inpatient bed) were included for all analyses of total ED LOS, and were categorized under their admitting service. These patients were excluded from the analysis of TTB (boarding time) given that they never reached an inpatient bed.

Data analysis

The mean total ED LOS and TTB were calculated for each admitting service. Previous years' trends (obtained from the Ontario Ministry of Health's iPORT Access tool) with respect to ED wait times show that these wait times were highly right-skewed, and that mean or median wait times did not fully capture the experience of those patients with more extreme prolonged wait times.[20] We therefore performed further analyses on those patients with prolonged ED LOS and prolonged TTB for each service. Prolonged ED LOS was determined *a priori* as ≥ 24 hours, and prolonged TTB was determined *a priori* as ≥ 12 hours. Using logistic regression, odds ratios (OR) were calculated for prolonged ED LOS and prolonged TTB as a function of the patient's admitting service using the surgical service as the reference.

Further exploratory analysis was conducted to identify the major predictors of prolonged ED LOS and TTB. Both within the literature and within our initial preliminary analyses, patients admitted to the medicine service experienced the greatest delays in transfer to inpatient beds.[21] Therefore, we conducted these secondary analyses *only* within those patients admitted to medicine, to eliminate any confounders relating to admission service. We sought to determine the impact of patient age, patient comorbidity, requirement for an isolation bed or telemetry bed, and day of the week of patient registration on ED LOS and TTB. For patient age, we first conducted a linear regression analysis to determine the existence of an association between age and 1) ED LOS and 2) TTB. We then categorized
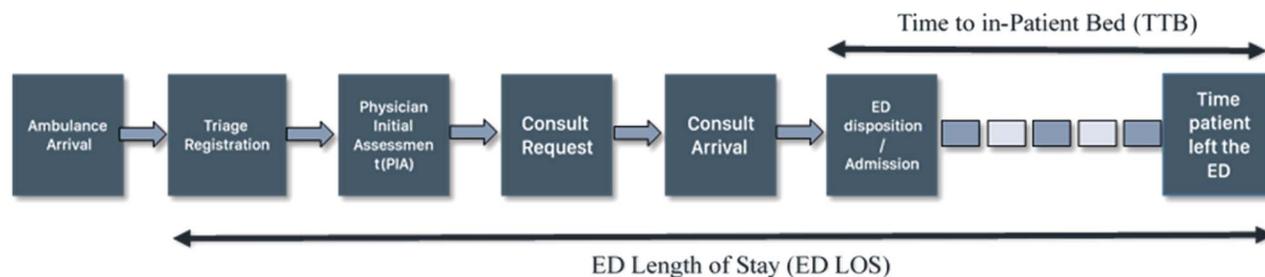

Figure 1. Schematic representation of different metrics measured during the course of a patient's ED journey.

patient age into four categories based on the quartile cut-offs of our sample population. Our age categories were ages less than 56, ages 56 to 69, ages 70 to 80, and ages ≥ 81. Using logistic regression analysis, we calculated unadjusted and adjusted OR for prolonged ED LOS and prolonged TTB for each variable. Our adjusted model included all variables of isolation status, telemetry requirement, age category, and comorbidity level.

To determine whether prolonged ED wait times were associated with clinically relevant outcomes, we first used logistic regression to calculate OR for inpatient mortality as a function of both TTB and ED LOS for patients admitted to the medicine service. Secondly, unadjusted and adjusted mean total IP LOS were calculated for those with prolonged ED LOS and TTB versus those without prolonged ED LOS and TTB. One-way analysis of variance (ANOVA) tests were performed to determine the statistical significance of the difference in mean IP LOS among those with prolonged ED LOS and TTB versus those without. Further analysis using multivariate linear regression was conducted to adjust group means for comorbidity level, age category, isolation status, and telemetry requirements.

All analyses were conducted using SAS statistical software program version 9.4 for Windows, SAS Institute Inc. (Cary, North Carolina).

Ethics approval was obtained through the William Osler Health System Research Ethics Office.

RESULTS

The initial study population included 18,250 unique inpatient admissions. Of these, 13,872 admissions were to the four services of interest, and 4,319 admissions were to other services. Of the 13,872 admissions in the cohort, 1,053 (7.6%) admission events were ultimately discharged from the ED without reaching an inpatient bed. Fifty-nine admission events had missing data on admission unit or service. Descriptive characteristics of patients, total ED LOS, and total TTB by admission service appear in Table 1. The one-way ANOVA test showed a statistically significant difference between group means ($p < 0.0001$) for mean ED LOS and mean TTB among patients admitted to the four different services. Patients admitted to Medicine had a mean ED LOS of 25.6 hours and a mean TTB of 15.9 hours. Pair-wise comparisons showed this difference to be significantly ($p < 0.0001$) greater than ED wait times for patients admitted to the other three services (see Table 1). As well, there is a significant difference in odds of prolonged ED LOS and prolonged boarding time (i.e., TTB) as a function of admitting service, with patients admitted to medicine having a far greater odds of prolonged wait time in the ED:

OR (confidence interval [CI]) for prolonged ED LOS: medicine, 29.5 (23.2-37.4); critical care,

Table 1. Baseline characteristics of sample population					
	Study population	Medicine	Surgery	Critical care	Pediatrics
Unique admissions, number (%)	13,872	8,228	2,440	1,549	1,655
Age (yr) (Mean, SD)	57.1 (26.1)	67.1 (17.8)	55.0 (20.8)	62.0 (16.9)	5.4 (5.8)
Sex					
Female	6,791 (49.0%)	4,109 (49.9%)	1,339 (54.9%)	641 (41.4%)	702 (42.4%)
Male	7,081 (51.1%)	4,119 (51.1%)	1,101 (45.1%)	908 (58.6%)	953 (57.6%)
Comorbidity level					
0	7,374 (53.6%)	3,332	1,902	662	1,478
1	1,989 (14.5%)	1,491	182	198	118
2	1,836 (13.4%)	1,445	131	212	48
3	1,559 (11.3%)	1,233	75	242	9
4	998 (7.3%)	724	42	232	0
Mean comorbidity level	1.04	1.33	0.36	1.47	0.15
Mean CTAS score	2.2	2.2	2.4	1.8	2.1
Total ED LOS (hr), mean (SD)	19.2 (14.3)	25.5 (14.6)	10.0 (5.6)	11.0 (8.9)	8.5 (4.4)
Prolonged ED LOS (≥24 hours), number (%)	4,102 (29.6%)	3,888 (47.3%)	72 (3.0%)	119 (7.7%)	23 (1.4%)
Total boarding time (TTB) (hr), mean (SD)	11.1 (13.1)	18.1 (14.64)	4.0 (4.4)	5.5 (8.1)	3.3 (4.0)
Prolonged boarding time (TTB), number (%)	5,133 (37%)	4,760 (57.8%)	106 (4.34%)	211 (13.6%)	56 (3.4%)
Total inpatient LOS (days), mean (SD)	6.2 (9.7)	6.9 (9.6)	4.6 (7.4)	9.0 (15.5)	2.3 (2.5)

CTAS = Canadian Triage Acuity Scale; ED = emergency department; LOS = length of stay; SD = standard deviation; TTB = time to bed.

2.7 (2.0-3.7); pediatrics, 0.5 (0.3-0.7); and OR (CI) for prolonged TTB: medicine, 31.4 (25.5-38.7); critical care, 3.6 (2.9-4.7); pediatrics, 0.7 (0.5-1.0).

We found the distribution of wait times among the cohort of patients admitted to the four services to be highly right-skewed. Figure 2 shows the distribution of TTB for our population (the distribution of total ED LOS can be found in Supplementary Table 1 and Supplementary Figure 1). This figure shows that the total cumulative patient-hours of boarding time for all patients whose boarding times were greater than the median boarding time (N = 6,936 patients) were nearly eight times higher than the cumulative patient-hours of boarding time of those patients whose boarding times were less than the median.

When examining patients admitted to the medicine service, we found that the odds of prolonged wait in the ED (either as prolonged ED LOS or prolonged TTB) were significantly greater for those under isolation, for those under telemetry, for older patients, and for those with a greater comorbidity burden. The direction and magnitude of ORs for these patient-specific factors were similar for both exposure variables of prolonged TTB (Table 2) and ED LOS (see Supplementary Table 1). The day of the week of admission was also associated with

significant differences in odds of prolonged ED wait times (both ED LOS and TTB) for those who presented to the ED on Sundays and Mondays (see Table 2 and Supplementary Table 1).

For those patients admitted to the Medicine service, the logistic regression analysis of the association between inpatient mortality and prolonged ED wait times revealed no statistically significant greater odds of mortality for those with prolonged ED LOS (OR: 0.9, 95% CI: 0.7-1.0) or prolonged TTB (OR: 0.9, 95% CI: 0.8-1.1). There was, however, a statistically significant greater mean IP LOS for those who had prolonged wait times in the ED (Table 3). This increased IP LOS and persisted even after correcting for age category, isolation status, telemetry requirements, and comorbidity level.

DISCUSSION

Findings of the most recent studies on the issue of ED overcrowding have challenged some of the conventional wisdom around root causes of ED congestion. With respect to input factors, it is commonly believed by both the lay public and, to some degree, hospital administrators and policymakers that ED overcrowding is partly due to lack of timely access to primary care. However, studies
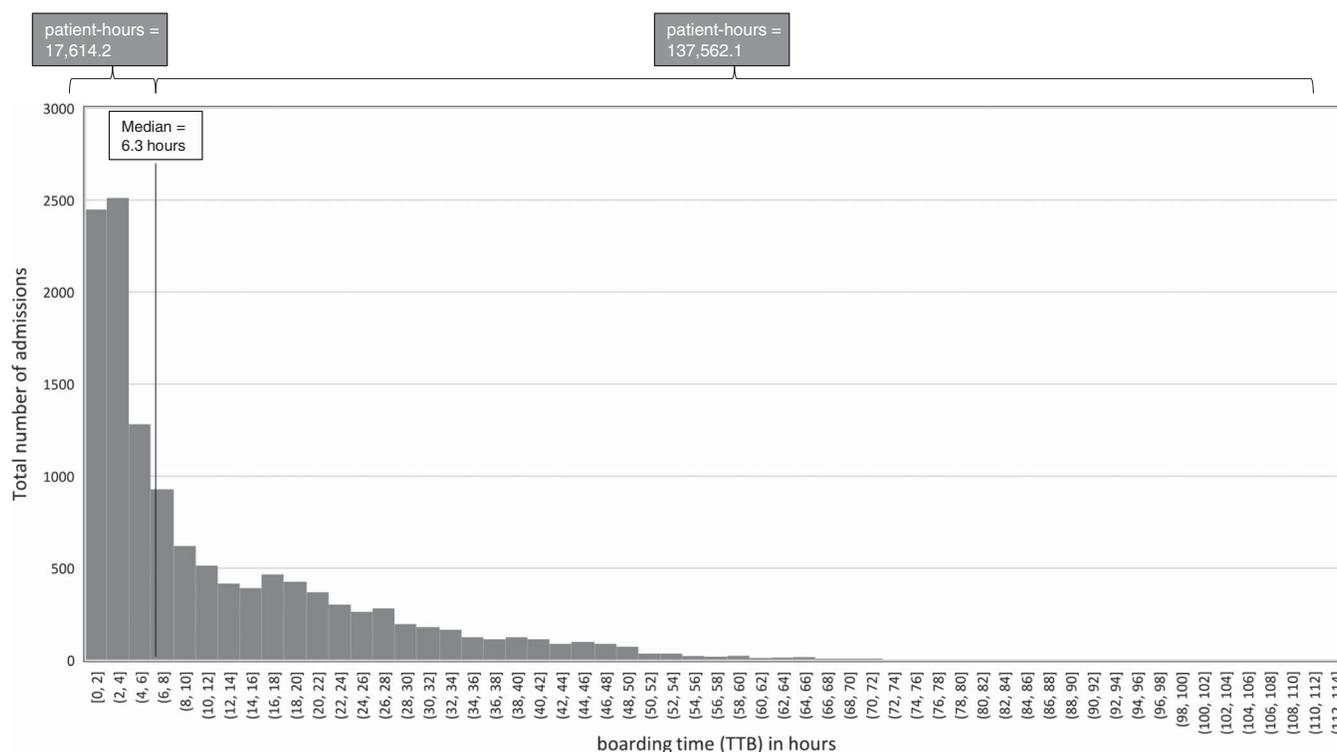

Figure 2. Distribution of boarding times (TTB), 2015.

Table 2. Unadjusted and adjusted odds ratios for prolonged boarding time (TTB) as a function of patient characteristics

	Odds ratios			
	Unadjusted		Adjusted	
Prolonged boarding time(TTB ≥ 12 hours)	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Telemetry status	1.9	1.8-2.2	2.1	1.9-2.4
Isolation status	1.9	1.7-2.1	1.9	1.7-2.2
Age category				
(reference: age category 1)	Ref		Ref	
Age category 2	1.2	1.1-1.4	1.1	1.0-1.3
Age category 3	1.6	1.4-1.9	1.4	1.2-1.7
Age category 4	1.7	1.5-2.0	1.5	1.3-1.8
Comorbidity level				
(reference: comorbidity level 0)	Ref		Ref	
Comorbidity level 1	1.2	1.0-1.4	1.1	1.0-1.3
Comorbidity level 2	1.1	1.0-1.3	1.1	1.0-1.2
Comorbidity level 3	1.5	1.3-1.7	1.4	1.2-1.6
Comorbidity level 4	1.7	1.4-2.0	1.5	1.2-1.8
Day of the week				
(reference: Friday)	Ref			
Monday	1.9	1.6-2.2		
Tuesday	1.7	1.4-2.0		
Wednesday	1.6	1.4-1.9		
Thursday	1.5	1.3-1.8		
Saturday	1.4	1.2-1.6		
Sunday	1.9	1.6-2.3		

TTB = time to bed.

have in fact shown that the volume of low-complexity, low-acuity patients has a negligible impact on overall ED flow and operations.[22-24] As well, improved access to primary care has not been consistently correlated with improved ED overcrowding metrics.[23,25,26] For those patients with chronic ambulatory care sensitive conditions, a recent CIHI report showed that these patients represented a very small (4%) proportion of ED users, were judged to be of higher acuity than the overall ED patient population, and had a much higher rate of inpatient admission, suggesting that care within the ED is in fact very appropriate for such patients.[27] Studies have similarly found throughput issues to be a less significant barrier to ED flow than previously believed.[13,28-32]

In fact, current research suggests that hospital-wide issues – rather than factors internal to the ED such as ED staffing and resources – may be more important in determining ED efficiency and throughput.[8,10,27,33-36] Consequently, interventions that have had the most positive impact on ED congestion are those that target hospital-wide capacity and operations.[9,15,33,37-43]

Table 3. Unadjusted and adjusted mean inpatient length of stay for patients with prolonged ED wait times

	Mean inpatient length of stay (IP LOS) in days			
	Unadjusted		Adjusted	
MEDICINE	Mean (SD)	p-value	Mean	p-value
ED length of stay (ED LOS)				
<24 hours	6.26 (8.36)	<0.0001	7.9	<0.0001
≥24 hours	7.64 (10.69)		8.9	
Time to (inpatient) bed (TTB)				
<12 hours	6.8 (8.7)	<0.0001	8.3	<0.0001
≥ 12 hours	8.3 (10.7)		9.2	

The TTB metric is an important adjunct to the ED LOS metric, because it reflects resource and capacity factors and operational issues that lie outside of the ED. The prolonged ED wait times of the more complex patients (such as those admitted to the medicine service) highlight the variability of wait times as a function of the patient's resource utilization and burden of illness. In fact, within our study, the greatest mediator of

prolonged ED wait times appears to be the admitting service. Patients admitted to the Medicine service wait far longer in the ED than patients admitted to other services. Even within Medicine patients, those with the greatest comorbidity burden and more specialized resource needs (i.e., those requiring a telemetry or isolation bed) are shown to wait the longest in the ED. A similar relationship between age and comorbidity and higher ED LOS was found in other studies.[21,43-45] However, to our knowledge, few studies have attempted to quantify the impact of clinical and operations-related factors such as admission service, telemetry requirements, and isolation status on ED wait times. These wide disparities in wait times, in part, are likely a reflection of the complexity of the patient population (with pediatric and surgical patients being less complex and having more predictable total inpatient lengths of stay, than those admitted to Medicine), operational issues impacting the different organizational structures within these services, and systemic challenges in addressing the needs of more medically complex patients. Given the variability in the evidence, recommendations and practice patterns around isolation and telemetry requirements for admitted patients, this presents an area for potential intervention by clinicians and hospital administrators through auditing their current admissions practices and adopting institution-wide policies and pathways that are more in line with existing capacity.[46,47]

With respect to actual clinical outcomes, we found no statistically significant association between prolonged ED LOS and TTB and increased inpatient mortality. Within our sample population, those patients admitted to the medicine service were older, sicker, and had higher inpatient mortality rates than those admitted to the surgery and pediatric services. They also were disproportionately represented among those patients with prolonged ED LOS and TTB, confounding the association between ED wait times and inpatient mortality. Previous associations between inpatient mortality and increased ED LOS may have been driven in part by the confounding of admission service as a driver of both increased ED LOS (and increased boarding times) and increased inpatient mortality.[14,16,48,49]

Nonetheless, even when analysing only those patients admitted to the medicine service, and thereby eliminating the confounding effect of different admitting services, we found a positive correlation between increased ED wait times and greater total IP LOS. This association is likely multifactorial, reflecting both widespread organizational inefficiencies and wider health systems factors that impact the transfer of patients *into* the unit and discharge of patients *out* of the unit, in addition to any potential deterioration that the patient may suffer while waiting in a suboptimal ED environment. Finally, the finding of the extremely right-skewed distribution of boarding times is worthy of further exploration because it indicates that the issue of ED congestion and bed boarding is likely driven by a very small proportion of the total number of patients who present to the ED, and has implications for performance monitoring and process- and operations-level improvement.

Several limitations exist in this study. Firstly, it is a single-site study at a centre with a particularly high patient volume and consequent ED wait times. Other limitations include those endemic to observational studies of large databases, namely coding and measurement errors, effects of hidden confounders, and the identification of statistically significant but clinically inconsequential effects due to the large sample size. Finally, the variable of comorbidity level used in our study was developed primarily to provide a relative index of *cost* of resource consumption as a function of the patient's comorbidity burden. The inclusion of "facility" and "age" into the CIHI comorbidity level regression model impedes generalizability and may lead to collinearity with the age category variable in our model. However, one major advantage of comorbidity level as an indicator of comorbidity burden is that it measures resource utilization (particularly within a Canadian context) as opposed to other indices of comorbidity (e.g., Charleson Comorbidity Index), which are used to predict mortality, and include only a small number of comorbid conditions.

CONCLUSION

In summary, the findings of our study show that bed boarding within our centre is highly unequally distributed and overwhelmingly concentrated in the medicine service. As well, those patients who have higher resource requirements tend to have greater boarding times, and these prolonged boarding times are associated with greater IP LOS. Finally, the highly right-skewed distribution of ED boarding times indicates that ED overcrowding and congestion are likely greatly driven by a relatively small proportion of the

total number of patients who visit the ED. These findings – while requiring further exploration and research – highlight the pitfalls of more universal, untargeted interventions to resolve the issue of ED overcrowding.

SUPPLEMENTARY MATERIALS

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/cem.2018.18

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