Pediatric ED departmental complexity: a different approach to the concept of ED crowding

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Abstract

Objective Emergency department (ED) crowding is a significant problem in Canada and internationally and is associated with the potential for patient harm. Although pediatric patients represent a significant proportion of overall ED visits, there is limited research on pediatric ED crowding. The Canadian Association of Emergency Physicians defines department crowding as a mismatch between the required and available resources to provide timely emergency care. We propose that rather than crowding, it is better to think of ED patient populations as being more or less “complex” as defined by proxies of the human and physical resources needed for patient management. The study objectives are to explore the utility of a simple and easily available retrospective metric of ED complexity, and to assess the relationship this measure has on patient outcomes in a pediatric ED.

Methods Using administrative data from a tertiary care pediatric ED, we developed a departmental complexity score based on patient registration number, triage acuity, and departmental length of stay as a proxy for the resources necessary to provide ED care. We then explored the relationship between this departmental complexity score and clinical care indices.

Results The score shows a strong relationship with the number of patients who left without being seen by a physician, as well as time to initial MD assessment, both measures which have been used to represent ED crowding in previous research. We found no association between our departmental complexity score and adverse impacts on patient care outcomes of hospital admission, pediatric ICU admission, or patients returning to the ED within 72 h of leaving.

Conclusions The departmental complexity score has promise as a retrospective measure of departmental resource requirement and may have a role in the ongoing assessment of patient flow.

Keywords Emergency medicine · Pediatrics · Emergency department crowding

Résumé

Objectif L'encombrement des services d'urgence est un problème important au Canada et à l'échelle internationale et est associé à un risque de préjudice pour les patients. Bien que les patients pédiatriques représentent une proportion importante de l'ensemble des visites aux urgences, il existe peu de recherches sur l'encombrement des urgences pédiatriques. L'Association canadienne des médecins d'urgence définit l'encombrement des services comme une inadéquation entre les ressources nécessaires et les ressources disponibles pour fournir des soins d'urgence en temps opportun. Nous proposons que, plutôt que de parler d'encombrement, il est préférable de considérer les populations de patients des urgences comme étant plus ou moins “complexes”, selon des approximations des ressources humaines et physiques nécessaires à la prise en charge des patients. Les objectifs de l'étude sont d'explorer l'utilité d'un indicateur rétrospectif simple et facilement accessible de la complexité des urgences, et d'évaluer la relation de cet indicateur sur les résultats des patients dans des urgences pédiatriques.

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Méthodes En utilisant les données administratives d'un service d'urgence pédiatrique de soins tertiaires, nous avons développé un score de complexité départementale basé sur le numéro d'enregistrement du patient, l'acuité du triage et la durée du séjour départemental comme un indicateur des ressources nécessaires pour fournir des soins d'urgence. Nous avons ensuite exploré la relation entre ce score de complexité départementale et les indices de soins cliniques.

Résultats Le score présente une forte relation avec le nombre de patients qui sont partis sans être vus par un médecin, ainsi qu'avec le délai avant l'évaluation initiale du médecin, deux mesures qui ont été utilisées pour représenter l'encombrement des urgences dans des recherches antérieures. Nous n'avons trouvé aucune association entre notre score de complexité départementale et les effets négatifs sur les résultats des soins aux patients de l'admission à l'hôpital, de l'admission en unité de soins intensifs pédiatriques ou des patients qui reviennent aux urgences dans les 72 heures suivant leur départ.

Conclusions Le score de complexité départementale est prometteur en tant que mesure rétrospective des besoins en ressources départementales et peut jouer un rôle dans l'évaluation continue du flux de patients.

Clinician's capsule

What is known about the topic?

Emergency department (ED) crowding of significant concern to clinicians, and though an intuitive concept, it is difficult to define and measure.

What did this study ask?

Rather than the term crowding, we propose the term 'complexity' to represent the resource demands on a department.

What did this study find?

The complexity score correlates strongly with patients who leave prior to physician assessment and ED wait times, both measures associated with ED crowding.

Why does this study matter to clinicians?

The complexity score has potential as a measure of departmental resource requirements and in the assessment patient flow and pediatric ED crowding.

Asplin et al. described a conceptual model considering ED crowding in terms of input (patients presenting to the ED), throughput (processes related to patient care) and output (hospitalization, transfer or discharge) [6]. Previous studies have identified patient volume (input) and ED process factors (throughput) as important drivers of pediatric ED crowding, [7, 8], though output factors (admitted patients awaiting inpatient beds or access block) may be an emerging concern in pediatric departments [4]. Defining pediatric emergency departmental crowding is difficult. The number of patients presenting for ED care may be of primary importance [7], but acuity and other patient care factors can impact the processes of care [8]. Departmental crowding may, therefore, be considered a multi-dimensional parameter, encompassing census, but also acuity and subsequent clinical workload. Consequently, we believe that it is better to think of the pediatric ED as being more or less "complex" as defined by proxies of census, acuity and clinical workload, reflecting the resources necessary to provide care. We analyzed patient visit data to:

- (1) Explore the utility of a simple and easily available retrospective metric of ED complexity.
- (2) Assess the relationship this measure has on patient outcomes in a pediatric ED.

Introduction

Emergency department (ED) crowding is a major global healthcare issue [1]. In a 2007 survey of Canadian EDs, 62% reported that crowding was a major or severe problem [2]. Understanding the causes and impact of crowding on pediatric patients is hindered by the lack of a single accepted ED crowding metric in addition to limited published research on pediatric ED crowding [3, 4].

ED crowding has been defined by the Canadian Association of Emergency Physicians (CAEP) "*as a situation where the demand for care exceeds the ability of an emergency department to provide care within appropriate time frames.*" [5]. This definition suggests that crowding arises from insufficient resources available to meet the demand for care [5].

Methods

Design

This is a database analysis, in which input and throughput parameters (census, high acuity census, and sum of active care time) were used to provide a multidimensional proxy of the clinical workload in a tertiary pediatric ED. We assessed the relationship between this proxy and clinical outcomes (time to doctor, and rates of leaving without being seen, admission, and return to ED). We assessed confounders (changes in physician scheduling, seasonality, and year over year changes in administrative changes in care). The study has been approved by the IWK research ethics board.

Study population

Pediatric emergency visits (aged 0–15 years inclusive) at the IWK hospital in Halifax, Nova Scotia, from April 1, 2007 to August 31, 2018 (4170 unique dates; annual census approximately 28,000 visits per year).

Data sources

Our institution regularly submits data to the Canadian Institute of Health Information's (CIHI) National Ambulatory Care Reporting System (NACRS) [8]. To make up the dataset, trained data abstractors review each ambulatory chart and perform high-level cleaning and error detection. Since 2007, we have archived an excerpt of these data, named as the ED Visits Database, that references all ED visits. At time of study, this dataset was complete from April 1, 2007 to August 31, 2018. We also accessed the final as-scheduled physician roster, available from June 28, 2010 to June 30, 2018.

Analysis

For each visit, we obtained triage level (CTAS), critical care times, disposition (admit, discharge, transfer, died, left without being seen), triage month, year and hour. For evening visits (see below), we calculated time to physician and active treatment time (the time from first physician contact to the time of patient disposition) and noted any returns to ED within 72 h. From the physician's schedule, we extracted the number of physician hours for each evening.

We calculated the departmental clinical complexity in the afternoon (noon to 18:00) of each date and took our outcome measures from corresponding evening (18:00 to midnight) to ensure that our input and output variables did not confound each other. Further, the hours between noon and midnight are the busiest, with a plateau in wait times in the evenings. Afternoon departmental complexity was derived using the

sums of total afternoon census, total afternoon high acuity census (CTAS scores of 1–3) and afternoon active treatment time. For each date, these sums were inspected to determine if the value was within one standard deviation of the average for the fiscal year of the visit (score = 0), or outside of this range (– 1 if low, + 1 if high). For each date, a sum of these sub-scores was obtained. For example, a departmental complexity score of + 3 would indicate an afternoon in which census, acuity, and active treatment times are all one standard deviation above the mean for that fiscal year (Fig. 1).

Data were imported into a Microsoft Access™ database and queries written to produce final tables for analyses. Summary statistics, regression and Pearson correlation were then performed using Microsoft Excel™ and Minitab™ (Fig. 2).

Results

Correlates between afternoon and evening input variables

Total census, high acuity census and active treatment time showed moderate to high individual correlation between afternoon and evening using the Pearson correlation coefficient (afternoon to evening total census: $r=0.36$; high acuity census: $r=0.53$; sum active treatment time: $r=0.47$).

Departmental complexity and output variables

We performed multivariate regression using evening doctor numbers and departmental complexity as predictor variables. Time to doctor was significantly greater for all CTAS groupings at higher departmental complexity values (Fig. 3), and departmental complexity was an independent predictor of time to doctor for all CTAS groupings ($p < 0.0001$ for each group). Evening doctor numbers were an independent predictor of time to doctor for higher acuity groups (CTAS 3, CTAS 1 and 2, $p < 0.001$ for each) but not for CTAS 4

Fig. 1 Derivation of departmental complexity score

Fig. 2 Calculating patient outcomes. *LWBS* left without being seen

Fig. 3 Time to doctor vs departmental complexity score

and 5. A similar analysis showed left without being seen rates were much higher with higher departmental complexity scores (Fig. 4), and that departmental complexity was an independent predictor of left without being seen rates ($p < 0.0001$). Evening doctor numbers were not significantly associated with left without being seen. Departmental complexity was not associated with admission rates, admit to ICU rates, or rates of return within 72 h.

Finally, comparing our peak patient flow season (December through March inclusive) with summer (June to August inclusive: our slowest season), we found similar results. Multivariate regression showed that departmental complexity was an independent predictor of time to doctor in our peak season for all CTAS groupings ($p < 0.0001$) and was an independent predictor of time to doctor in the CTAS 1

and 2, and CTAS 3 groups in our summer (slowest) season. Departmental complexity did not predict time to doctor in the summer season for CTAS 4 and 5. Complexity was an independent predictor of left without being seen rates in both peak ($p < 0.001$) and summer ($p = 0.002$) seasons.

Discussion

Interpretation of findings

Multiple studies have assessed potential definitions and markers of ED crowding though there are no agreed upon definitions or measurement standards [3]. Previous pediatric studies suggest that number of patients presenting for care

Fig. 4 Left without being seen rates vs departmental complexity

and ED processes are the main factors contributing to pediatric ED crowding, and that left without being seen and time to MD assessment reflect ED crowding [7, 8].

Instead of crowding, we define the complexity of our department based on the ED patient population, using easily available measures of input encompassing patient volume, proportion of higher acuity patients, and throughput indicated by ED active treatment time, to which acuity is a likely contributor [9]. The derived complexity score is not intended to isolate individual factors contributing to ED flow, but rather provides a composite measure of the resource demands, reflecting the conditions into which patients present for care during the evening peak hours in our tertiary care pediatric ED. Our guiding assumption in this work was that any ED shift which had a higher number of registrants, a higher number of acute patients, and a greater sum of active treatment time could be rationally considered to be more “crowded”, or “complex”, and that a multi-dimensional score reflecting these conditions was a more natural way to explore resource demand in the ED. Consequently, it allows for the differentiation between a high flow of low acuity children (for example, during viral epidemics) and a similarly numbered flow of higher acuity individuals (for example, an evening peppered with the arrival of multiple trauma victims). These are clearly different scenarios, for which the term “complexity” is preferable and more differentiating than the term “crowding”.

Our study found a strong correlation between complexity score of a shift and percentage of patients leaving without being seen for medical assessment. Left without being seen has been used as a marker of ED crowding in several studies [10], and is considered a measure of ED performance in both pediatric and adult departments [8]. We also found a

significant relationship between the complexity score and time to MD assessment for urgent, less urgent and lower acuity patients (CTAS levels 3, 4 and 5), and a significant but reassuringly less marked relationship for higher acuity patients (CTAS 1 and 2). The relationship between departmental complexity and left without being seen remained significant when considered by peak (winter) and slow (summer) seasons.

Comparison to previous studies

Several studies have suggested adverse outcomes associated with ED crowding, including a 2011 study by Gutmann et al. from Ontario found that adult patients discharged from a crowded ED (defined by shifts with longer wait times) experience higher rates short-term morbidity and mortality [11]. Although a higher complexity score was associated with longer wait times for MD assessment and a higher rate of left without being seen, there were no increases in hospitalization, pediatric ICU admission, or patients returning to the ED in the 72 h following the index visit. Our findings are similar to those of a recent multi-centre. Canadian study which analyzed nearly 2 million visits over 5 years across 8 pediatric ED’s, finding no association between ED crowding and adverse patient outcomes [12]. The study by Doan et al. however, observed a small increase in hospitalization of higher acuity patients and increased return visits of lower acuity patients associated with ED crowding [12].

Although our composite measure of complexity has not been previously used to assess crowding, the departmental complexity score showed a strong correlation with left without being seen and physician wait times. Our ED complexity score was not compared to previously published composite

scores of ED crowding: NEDOCS [7], EDWIN [13], or ICMED [14], which include factors that may not be applicable to pediatric ED crowding in Canada such as boarded inpatients awaiting beds, delayed ambulance off-loading, or ventilated patients in the ED.

Strengths and limitations

This study began as a quality assurance project to investigate patient outcomes associated with ED crowding in a single pediatric ED. The definition and markers chosen were based on availability in our ED administrative dataset, as well as patient flow characteristics identified from the published literature on pediatric ED crowding. We separated measurement of complexity and collection of outcome variables by assessing these at different points in the shift focusing on the busiest part of the day. While this allowed us to avoid confounding outcomes, it is possible that departmental complexity changed over those time periods, the moderate to high correlation between the afternoon input variables and evening output calculations notwithstanding. Although our study is retrospective and uses routinely collected administrative data, the large patient population and number of shifts analyzed are strengths. The database analysis, however, does not allow assessment of individual patient outcomes.

Clinical implications

We feel that the departmental complexity score has promise as a retrospective measure of departmental resource requirement for future patient flow research or quality assurance projects. More study is needed to evaluate the wider applicability of this tool, i.e. whether it can be applied at the patient level rather than the shift level. An important question is whether a similar tool can be developed for prospective use.

Research implications

Our study uses department level data to test the concept of departmental complexity in the context of pediatric ED crowding, with a view to providing a starting point for additional research. Because our score uses the department's own historical patient flow data to establish the degree of complexity of any given period, our findings support the value of the score in a typically functioning emergency department, i.e. one that has variation in patient flow and acuity, with some relatively slow periods in which there is an excess of resources to patient need, as well as relatively busy periods where need

exceeds resources. The use of the standard deviation (rather than absolute numbers) potentially makes the concept scalable to departments of different sizes.

Conclusions

Using readily available administrative data from our tertiary care pediatric ED, a measure of departmental complexity was developed based on patient volumes, acuity, and active ED treatment time, reflecting the resources necessary to provide ED care. The departmental complexity score showed a strong correlation with the number of patients who left without being seen by a physician as well as wait times for MD assessment, suggesting that the score is representative of crowding in our tertiary care pediatric ED. Our study found no association between departmental complexity and adverse impacts on patient care outcomes. The departmental complexity score has promise as a retrospective measure of departmental resource requirement and may have a role in the ongoing assessment of patient flow. More study is needed as to its applicability at the patient level, and whether a similar tool can be developed for prospective use.

Declaration

Conflict of interest The author's declare there is no conflict of interest.

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