Emergency department occupancy is useful as a simple real-time measure of crowding

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Abstract

Introduction Emergency department (ED) crowding compromises patient outcomes. Existing crowding measures are complex and difficult to use in real-time. This study evaluated readily available single flow variables as crowding measures.

Methods Over 2 weeks in a tertiary Canadian ED, we recorded the following potential crowding measures during 168 consecutive two-hour study intervals: total ED patients (census), patients in beds, patients in waiting rooms, patients in treatment areas awaiting MD assessment; number of inpatients boarding, and ED occupancy. We also calculated four complex crowding scores—NEDOCS, EDWIN, ICMED, and a local modification of NEDOCS. We performed ROC analyses to assess the predictive validity of these measures against a reference standard of *physician perception of crowding*.

Results We gathered data for 144 (63.9%) of 168 study intervals. ED census correlated strongly with crowding (AUC = 0.82, 95% CI 0.76–0.89), as did ED occupancy (AUC = 0.75, 95% CI 0.66–0.83). Their performance was similar to NEDOCS (AUC = 0.80) and to the local modification of NEDOCS (AUC = 0.83).

Conclusion ED occupancy as a single measure has similar predictive accuracy to complex crowding scores and is easily generalizable to diverse emergency departments. Real-time tracking of this simple indicator could be used to prompt investigation and implementation of crowding interventions.

Keywords Crowding · Emergency department

Résumé

Introduction L'encombrement des services d'urgence (SU) compromet les résultats pour les patients. Les mesures d'encombrement existantes sont complexes et difficiles à utiliser en temps réel. Cette étude a évalué des variables de débit unique facilement disponibles comme mesures d'encombrement.

Les méthodes Pendant deux semaines dans un service d'urgence tertiaire canadien, nous avons enregistré les mesures d'encombrement potentiel suivantes au cours de 168 intervalles d'étude consécutifs de deux heures : nombre total de patients dans le service d'urgence (recensement), patients dans les lits, patients dans les salles d'attente, patients dans les zones

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de traitement en attente d'une évaluation médicale ; nombre de patients hospitalisés en internat et occupation du service d'urgence. Nous avons également calculé quatre scores de surpeuplement complexes : NEDOCS, EDWIN, ICMED et une modification locale de NEDOCS. Nous avons effectué des analyses ROC pour évaluer la validité prédictive de ces mesures par rapport à une norme de référence de perception du surpeuplement par les médecins.

Résultats Nous avons recueilli des données pour 144 (63,9 %) des 168 intervalles d'étude. Le recensement des urgences est fortement corrélé avec le surpeuplement ($ASC = 0.82$, $IC\ 95\ \% = 0.76\text{--}0.89$), tout comme l'occupation des urgences ($ASC = 0.75$, $IC\ 95\ \% = 0.66\text{--}0.83$). Leur performance était similaire à celle des NEDOCS ($ASC = 0.80$) et à la modification locale des NEDOCS ($ASC = 0.83$).

Conclusion L'occupation des urgences en tant que mesure unique a une précision prédictive similaire aux scores complexes de surpeuplement et est facilement généralisable à divers services d'urgence. Le suivi en temps réel de ce simple indicateur pourrait être utilisé pour accélérer l'enquête et la mise en œuvre des interventions en cas de surpeuplement.

Clinician's capsule

What is known about the topic?

Validated measures of ED crowding are complex, resource-intensive and difficult to implement in real time.

What did this study ask?

Can a single measure predict emergency department crowding as accurately as validated complex crowding scores?

What did this study find?

ED occupancy is strongly predictive for crowding and performs equally well to the validated NEDOCS score.

Why does this study matter to clinicians?

ED occupancy is an easily available indicator, generalizable across EDs, that may provide a reliable real-time estimation of crowding, prompting early investigation and intervention.

Methods

Crowding predictors

Over a 2-week period in July 2014, research assistants recorded flow measures during 168 consecutive 2-h intervals. Research assistants documented six single measures, including ED census (total patients), patients in beds, patients in the waiting room, patients in treatment areas awaiting physician assessment, number of inpatients boarding, and ED occupancy, defined as ED census divided by staffed ED beds (42 during the day, 24 overnight). Research assistants also compiled three multivariable crowding scores: EDWIN (ED Work Index), NEDOCS (National ED Overcrowding Score), and ICMED (International Crowding Measure in EDs) [4–6], as well as our local saturation calculator (SAT) based on NEDOCS. Crowding score descriptions are available in the Methods Supplement.

Outcome

Our reference standard for crowding was physician perception, assessed using a 10 cm visual analogue scale (VAS) (0 = not crowded; 10 = extreme crowding), by asking the in-charge physician the following question: *How crowded do you think this ED is at the moment?* [6] Physicians were unaware of other measures being concurrently tracked. The team lead nurse independently provided a VAS crowding assessment for each relevant interval, and we calculated intraclass correlation coefficient to assure interrater reliability [7].

Analysis

In keeping with previous research [4–6], we dichotomized physician VAS ratings to designate non-crowded (VAS 0–4.9) and crowded (VAS 5–10) periods. We correlated each of the crowding measures with physician impression,

Introduction

Emergency department (ED) crowding is a worldwide problem with implications for patient care, system capacity and staff satisfaction [1, 2]. No consensus exists on how to best measure ED crowding. At least eight formal crowding scores have been developed with varying validity and applicability [2] but most are complex, time-consuming, and difficult to use in real-time. Indicators of crowding should be simple, easily available in real-time, and maintain reliability and accuracy across many EDs [3]. We examined the predictive validity of six single measures, as well as four complex crowding scores [4–6], for identifying ED crowding at a tertiary Canadian hospital.

and performed receiver operating characteristic (ROC) curve analysis to examine predictive validity. We reported area under the curve (AUC) values ranging from 0 to 1, with 0.50 indicating chance prediction, and values of 0.56, 0.64, and 0.71 reflecting small, medium and large effect sizes. Prior to reporting, we checked for collinearity and autocorrelation, finding that neither were threats to the analysis.

Results

Research assistants were available to capture data for 144 of 168 possible two-hour intervals. Physicians defined 92 of these (64%) as crowded. Intraclass correlation coefficient for VAS crowding assessments was 0.6 indicating moderate inter-rater agreement [7]. Single variables demonstrated effect sizes comparable to formal crowding scores and to SAT (Table 1). ED census emerged as the best single variable (AUC = 0.82) and was similar to NEDOCS (AUC = 0.80) and SAT (AUC = 0.83). Considering estimate precision (confidence ranges), ED occupancy (census/beds, AUC = 0.75) performed similarly to ED census, NEDOCs and SAT, and had stronger predictive validity than EDWIN or ICMED. Number of patients occupying ED beds (AUC = 0.76) and number in the waiting room (AUC = 0.79) also performed well, but inpatient admissions (AUC = 0.60) and patients waiting to be seen (TBS) (AUC = 0.59) were not significant predictors of crowding.

Table 1 Predictive validity of single variables and crowding scores for crowding ($N = 144$)

	AUC	95% CI
<i>Single variables</i>		
ED Census	.82	[.76–.89]
# patients in ED beds	.76	[.68–.84]
# patients in waiting room	.79	[.72–.87]
# inpatient admits	.60	[.49–.70]
# patients waiting TBS	.59	[.49–.68]
Occupancy	.75	[.66–.83]
<i>Crowding scores</i>		
EDWIN	.67	[.57–.77]
ICMED	.65	[.56–.74]
NEDOCS	.80	[.72–.88]
SAT	.83	[.76–.90]

AUC area under the curve, CI confidence interval, ED emergency department, TBS to be seen, EDWIN Emergency Department Work Index, ICMED International Crowding Measure in Emergency Departments, NEDOCS National Emergency Department Overcrowding Score, SAT local Saturation Calculator

Discussion

Rapid recognition of crowding facilitates timely process intervention, improved efficiency, expedited patient access, and reduced adverse events. This study showed a significant correlation between ED occupancy, NEDOCS and physician perception of crowding. We found that single easily calculated measures—ED census, number of patients in ED beds, patients in the waiting room, and ED occupancy—performed comparably to the best complex crowding scores. Of these, ED occupancy, that is, the ratio of ED census to bed capacity, is the most generalizable to diverse EDs.

ED crowding is a serious problem, but how to measure it remains unclear. A recent survey of Australian and New Zealand ED directors [8] found that the biggest challenge in crowding measurement is the choice of metric. Waxman and colleagues suggested ED census is a useful measure by showing it is associated with the number of patients who left without being seen and ambulance diversion rates [9]. McCarthy and colleagues found that the composite of occupancy, left without being seen and ambulance diversion is a moderately accurate crowding measure; however, left without being seen and ambulance diversion are relatively infrequent and not useful as real-time indicators [10]. Complex crowding scores like those studied here can be electronically calculated in some systems, but are often onerous in the calculation, and ultimately do not seem to perform better.

One of the most critical factors influencing crowding in the ED is hospital access block. Innes and colleagues [1] proposed the concept of facility access gap to emphasize the need for system wide co-operation: accountability for the access block is shared throughout the system and managers must create marginal efficiencies to reduce the access gap. The causes of ED crowding are dynamic and may related to combinations of inflow, throughput and outflow, however, the access gap process requires timely indicators in order to improve access. ED Occupancy is a simple, readily available measure of overall crowding, and may provide this early indicator.

After identifying a crowding situation based on ED occupancy, it is helpful to ascertain the immediate contributors, because solutions and mitigating strategies differ based on whether crowding is caused by inflow, throughput or outflow factors, or some combination. Therefore, facilities should also track more specific measures that highlight these three causes of ED crowding: inflow (N patients in the waiting room, ambulance offload time), throughput (wait time to see MD, time seen by MD to disposition time) and output (N inpatient boarders, ED length of stay for boarders). Hospital systems could therefore

first identify the existence of crowding in real time using Occupancy, then in a second stage examine the factors contributing to the local crowding circumstance and rapidly implement interventions like those suggested by Innes et al. [1].

Limitations

There is no gold standard measurement of ED crowding so, like multiple previous studies, we used ED physician perception [4–6]. Physician perception is pragmatic and reflects observations on time, occupancy and workload, although we found it had only moderate interobserver reliability [8]. In addition, because the same nurse and physician provided several VAS crowding estimates during each shift, these estimates were not independent and our reliability estimates may be artificially inflated. Future research should investigate alternatives to this subjective gold standard. Second, single variables and crowding scores are not mutually exclusive and have a high degree of conceptual overlap. Third, while physicians did not participate in the calculation of complex crowding scores, nursing team leaders were not blinded to the local SAT calculator; therefore, nurse VAS crowding evaluations may have been influenced by this NEDOCs-derived tool. Fourth, while crowding spans a continuum from absent to severe, we artificially downgraded VAS ordinal values to binary categories. Lastly, the study was performed over a 2-week interval at a single site. Our findings may not generalize to other sites and seasons; therefore external validation in different environments is required.

Conclusion

In this setting, single readily available flow measures performed as well as complex crowding scores. For reasons of generalizability, we suggest that ED occupancy is a valuable indicator to facilitate real-time crowding recognition, to drive rapid implementation of operational solutions, and for tracking and evaluation of crowding strategies over time.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s43678-021-00098-8>.

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Compliance with ethical standards

Conflict of Interest None.

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