

Optimal Measurement Interval for Emergency Department Crowding Estimation Tools

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Study objective: Emergency department (ED) crowding is a barrier to timely care. Several crowding estimation tools have been developed to facilitate early identification of and intervention for crowding. Nevertheless, the ideal frequency is unclear for measuring ED crowding by using these tools. Short intervals may be resource intensive, whereas long ones may not be suitable for early identification. Therefore, we aim to assess whether outcomes vary by measurement interval for 4 crowding estimation tools.

Methods: Our eligible population included all patients between July 1, 2015, and June 30, 2016, who were admitted to the JPS Health Network ED, which serves an urban population. We generated 1-, 2-, 3-, and 4-hour ED crowding scores for each patient, using 4 crowding estimation tools (National Emergency Department Overcrowding Scale [NEDOCS], Severely Overcrowded, Overcrowded, and Not Overcrowded Estimation Tool [SONET], Emergency Department Work Index [EDWIN], and ED Occupancy Rate). Our outcomes of interest included ED length of stay (minutes) and left without being seen or eloped within 4 hours. We used accelerated failure time models to estimate interval-specific time ratios and corresponding 95% confidence limits for length of stay, in which the 1-hour interval was the reference. In addition, we used binomial regression with a log link to estimate risk ratios (RRs) and corresponding confidence limit for left without being seen.

Results: Our study population comprised 117,442 patients. The time ratios for length of stay were similar across intervals for each crowding estimation tool (time ratio=1.37 to 1.30 for NEDOCS, 1.44 to 1.37 for SONET, 1.32 to 1.27 for EDWIN, and 1.28 to 1.23 for ED Occupancy Rate). The RRs of left without being seen differences were also similar across intervals for each tool (RR=2.92 to 2.56 for NEDOCS, 3.61 to 3.36 for SONET, 2.65 to 2.40 for EDWIN, and 2.44 to 2.14 for ED Occupancy Rate).

Conclusion: Our findings suggest limited variation in length of stay or left without being seen between intervals (1 to 4 hours) regardless of which of the 4 crowding estimation tools were used. Consequently, 4 hours may be a reasonable interval for assessing crowding with these tools, which could substantially reduce the burden on ED personnel by requiring less frequent assessment of crowding. [Ann Emerg Med. 2017;■:1-8.]

Please see page XX for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Crowding commonly occurs in the emergency department (ED) and is often associated with poor operations performance and negative patient outcomes.^{1,2} Patient total ED length of stay and number or rate of patients left without being seen or eloped are the metrics reported in daily ED operations in most US EDs. Increased ED length of stay and number or rate of left without being seen or eloped have been associated with increased levels of ED crowding reported in many studies in the literature.^{3,4} Meanwhile, meaningful interventions to decrease ED crowding are warranted, but they require early recognition

of crowding. Several ED crowding estimation tools have been developed and externally validated during the past 15 years to predict ED crowding.⁴⁻⁶ Nevertheless, little is known about the ideal frequency with which to measure ED crowding with these tools.

One of the most commonly used ED crowding tools is the National Emergency Department Overcrowding Scale (NEDOCS). NEDOCS was originally developed according to a 4-hour measurement interval, but subsequent studies used crowding measurement intervals ranging from 1 to 4 hours, without a clear justification for interval choice.⁷⁻⁹ Other ED crowding tools have also been developed and implemented, using inconsistent measurement intervals.

Editor's Capsule Summary*What is already known on this topic*

Emergency department (ED) crowding varies more within a day than across days.

What question this study addressed

How frequently should crowding be measured within a 24-hour period?

What this study adds to our knowledge

The variation in ED length of stay and left without being seen rates were compared across various crowding levels measured at 1-, 2-, 3-, and 4-hour intervals with 4 crowding tools. There was little meaningful difference in median ED length of stay and left without being seen rates across the 4 intervals.

How this is relevant to clinical practice

Measuring crowding every 4 hours is frequent enough to capture the effect that crowding has on ED length of stay and left without being seen rates.

For example, the Emergency Department Work Index (EDWIN),⁶ ED Work Score,¹⁰ and ED Occupancy Rate¹¹ use 4-, 2-, and 1-hour measurement intervals, respectively. The recently developed Severely Overcrowded, Overcrowded, and Not Overcrowded Estimation Tool (SONET) also uses a 2-hour measurement interval. The majority of ED crowding assessment requires ED personnel to manually collect variables for calculations. The burden of collecting multiple variables for different assessment tools increases with more frequent reporting of ED crowding.

Importance

Little empirical evidence is available to support any of the measurement intervals. Rather, the commonly used measurement intervals appear to be closely related to local hospital and ED policy. ED crowding reporting would be ideal in real time at the optimal measurement interval; however, higher-frequency crowding measurements by ED personnel might not always be feasible or be calculated precisely, especially during an extremely crowded status. Manual crowding assessment may still be common in EDs because electronic health record systems with the functionality to incorporate crowding measurement tools are not yet universal.¹² Therefore, unnecessarily narrow measurement intervals may burden ED resources without additional benefit in predicting crowding, whereas wide

measurement intervals may fail to detect crowding with sufficient lead time to allow intervention. A comparison of measurement intervals may thus be useful for identifying an optimal interval to balance outcomes and resources.

Goals of This Investigation

In this study, we aimed to assess whether outcomes varied by measurement interval (1, 2, 3, and 4 hours) for 4 crowding estimation tools.

MATERIALS AND METHODS**Study Design and Setting**

We conducted a cohort study with baseline assessment of ED crowding and follow-up measurement of outcomes for all patients who were admitted to the JPS Health Network ED between July 1, 2015, and June 30, 2016. This is an academic, tertiary care, Level I trauma center with more than 100,000 annual ED visits. The local institutional review board approved this study.

Selection of Participants

All patients who arrived at the study ED during the study period were enrolled. This project used the study institution's electronic health record to automatically retrieve data elements factored into calculation of relative ED crowding at the top of each hour (see detail in [Table E1](#) [available online at <http://www.annemergmed.com>] for the definition of all variables collected electronically). We included all crowding scores measured hourly during the study period, and no patient was excluded. Because this study used an electronic health record, there were no missing data. The quality of the data was evaluated by generating reports for the 4 crowding scores, study patient demographics (age, sex, race, mode of arrival, etc), and ED operations metrics (patient level of acuity, patient disposition, total ED length of stay, etc). Random samples of 20 time points were drawn in triplicate to evaluate data accuracy and consistency.

Methods of Measurement

To assess how suitable crowding measurement intervals are regardless of the specific scoring system used, we calculated relative ED crowding with 4 separate scoring systems: NEDOCS, SONET, EDWIN, and ED Occupancy Rate. Associations have been observed between each of these scoring systems and patient care outcomes; more detailed information on the derivation and validation of these scoring systems has been previously described.^{4-6,11}

In brief, NEDOCS is one of the most common ED crowding estimation tools. It was originally derived from

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