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EMERGENCY DEPARTMENT OCCUPANCY RATIO IS ASSOCIATED WITH INCREASED EARLY MORTALITY

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□ **Abstract—Background: To measure emergency department (ED) crowding, the emergency department occupancy ratio (EDOR) was introduced. Objective: Our aim was to determine whether the EDOR is associated with mortality in adult patients who visited the study hospital ED. Methods: We reviewed data on all patients who visited the ED of an urban tertiary academic hospital in Korea for 2 consecutive years. The EDOR is defined by the total number of patients in the ED divided by the number of licensed ED beds. We tested the association between the EDOR (quartile) and each outcome using a multivariable logistic regression analysis adjusted for potential confounders: age, sex, emergency medical services transport, transferred case, weekend visit, shift, triage acuity, visit cause of injury, operation, vital signs, intensive care unit or ward admission, and ED length of stay (quartile). The main outcome measures were survival status at discharge and at 1–7 days. Results: A total of 54,410 adult patients were enrolled. The EDOR ranged from 0.41 to 2.31 and the median was 1.24. On multivariable analyses, in comparison with the lowest (first) quartile, the highest (fourth) quartile of the EDOR was associated with 1-day mortality (adjusted odds ratio [OR] = 1.42; 95% confidence interval [CI] 1.08–1.88), 2-day mortality (adjusted OR = 1.31; 95% CI 1.04–1.67), and 3-day mortality (adjusted OR = 1.27; 95% CI 1.02–1.58). The EDOR was not significantly associated with 4- to 7-day mortalities and overall mortality at discharge. Conclusions: The EDOR is associated with increased 1- to 3-day mortality even after controlling for potential confounders.** © 2014 Elsevier Inc.

□ **Keywords—emergency department; crowding; poor outcome; emergency department occupancy ratio**

INTRODUCTION

Emergency department (ED) crowding has been a major problem of health care systems worldwide (1). During the past decades, the input-throughput-output model was the most widely accepted conceptual framework for ED crowding and many crowding measures regarding each step of this model have been introduced (2).

In 2008, McCarthy et al. proposed the emergency department occupancy rate (referred to here as the emergency department occupancy ratio [EDOR]) as a simple measurement of ED crowding (3). The EDOR is the ratio of the total number of patients in the ED to the total number of ED treatment bays. Because of its simplicity, the EDOR is easy to calculate and can be used in real-time situations. Researchers have demonstrated that the EDOR is significantly associated with a clinician's opinion of crowding, discrimination of diversion and left without being seen (LWBS), and poor treatment quality (3–8).

Despite agreement on the extent and adverse effects of ED crowding, there is no standard measurement for ED

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crowding among many ED crowding measurement tools (9,10). This implies that there is no single measure to meet the criteria, until now, that is easy to use or calculate, easy to trace in real time and therefore possible to use for early warning and planning, and validated as being associated with poor quality of care. The EDOR seems to meet all these criteria. However, until now, there has been no report showing the relationship between the EDOR and increased mortality in a large cohort. This study is important in the development of a consensus for standard measurement for ED crowding.

The present study aimed to determine whether the EDOR is associated with an increase in overall mortality in adult patients who visited the ED of the study hospital, even after adjusting for potential confounders. Because the effect on mortality of ED crowding is likely to be greatest early in a hospital stay and diminish over time, we determined outcomes that included 1- to 7-day mortality in addition to overall mortality. In the present study, the overall mortality includes in-hospital mortality and in-ED mortality. The EDOR was calculated using the visit data of adult and pediatric patients to the ED because the study hospital ED did not separate a treatment area for pediatric patients during the study period. However, considering the difficulty of age adjustment in pediatric patients, we analyzed the data of adult patients only.

METHODS

Study Design

We performed a retrospective analysis of all consecutive adult patients who registered in our ED between January 1, 2009 and December 31, 2010. This study was approved by the Institutional Review Board of the study hospital and a waiver for informed consent was obtained.

Setting and Selection of Participants

The study was conducted at a 1000-bed urban academic tertiary-care hospital. The study hospital has an electronic order communication system (OCS) in place. OCS is an integrated health information system that manages patient registration, medical data collection, and prescription management for patient care activities. The study hospital is a regional percutaneous coronary intervention (PCI) facility and is available for 24-hour interventions. The study hospital also serves as a regional trauma center. The study hospital offers medical, surgical, coronary, neurological, and pediatric intensive care unit (ICU) services. There are about 35,000 ED visits per year at the study hospital. All adult patients aged 15 years or older who visited the ED were considered eligible for the study.

In the hospital, all ED visitors must register in the OCS before they go to triage. At triage, all patients are checked for vital signs including systolic blood pressure, diastolic blood pressure, pulse rate, respiratory rate, body temperature, peripheral oxygen saturation, and central nervous system (CNS) status. CNS status is recorded using a scale of alert, verbal, painful, unresponsive (AVPU) in the study hospital ED. A triage nurse assesses acuity using a 5-point scale including immediate, emergency, urgent, semi-urgent, and non-urgent. A triage nurse enters this information into the OCS and prints the chart. After triage, a complete history is taken and a full physical examination is performed by the attending physician in the ED. Laboratory tests and radiologic evaluations are conducted as necessary. Medical records are computerized after patients are discharged.

There are three shifts in the study hospital, 7 am to 3 pm (day), 3 pm to 11 pm (evening), and 11 pm to 7 am (night). The same number of emergency doctors (n = 5) and emergency medical technicians (n = 2) worked in each shift. There are 9 nurses during the day, 10 during the evening, and 8 during the night shifts.

Methods of Measurement

The EDOR is defined as the total number of patients in the ED divided by the number of licensed ED beds. The numerator includes all patients in the ED at any point regardless of any throughput process after registration (i.e., triage, examination by doctors, diagnostic evaluation, treatment, and boarding). The denominator includes the total number of licensed treatment bays as defined by the ED's original blueprint, but excludes hallway locations. There were 42 licensed ED beds during the entire study period. There was no remodeling of ED areas during the study period.

The EDOR is calculated using collected OCS data when patients registered in the OCS. When patient "A" visited the hospital and registered in the ED, for example, if 41 patients are already in the ED before "A" visits, EDO becomes 42 (41 [previously existing patients] + 1 [new patient, "A"]) and EDOR becomes 1 (42 [total patients in the ED]/42 [licensed beds in the ED]).

Because the effect on mortality of ED crowding is likely to be greatest early in a hospital stay and diminish over time, we set the main outcomes of the survival status at days 1–7 regardless of patients' position at hospital, ED, or home. To determine survival status of patients who were not in the hospital each day, we investigated follow-up date of all enrolled patients using OCS. For patients for whom follow-up data were not available for day by day survival status, we treated their survival status as missing data. We also set overall hospital mortality as the main outcome. Because a negative effect of ED