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## Original Contributions

### IN-HOSPITAL SEPSIS MORTALITY RATES COMPARING TERTIARY AND NON-TERTIARY HOSPITALS IN WASHINGTON STATE

Gail G. Salvatierra, RN, PHD,\* Bernice G. Gulek, ACNP-BC, MS, RN,† Baran Erdik, MD, MHPA,†  
 Deborah Bennett, RN, PHD,\* and Kenn B. Daratha, PHD†‡§

\*School of Nursing, California State University San Marcos, San Marcos, California, †College of Nursing, Washington State University, Spokane, Washington, ‡Providence Medical Research Center, Providence Sacred Heart Medical Center, Spokane, Washington, and §Department of Medical Education and Biomedical Informatics, University of Washington, Spokane and Seattle, Washington  
 Reprint Address: Gail G. Salvatierra, RN, PHD, School of Nursing, California State University San Marcos, 333 S. Twin Oaks Valley Rd., San Marcos, CA 92096

□ **Abstract—Background:** More than a million people a year in the United States experience sepsis or sepsis-related complications, and sepsis remains the leading cause of in-hospital deaths. Unlike many other leading causes of in-hospital mortality, sepsis detection and treatment are not dependent on the presence of any technology or services that differ between tertiary and non-tertiary hospitals. **Objective:** To compare sepsis mortality rates between tertiary and non-tertiary hospitals in Washington State. **Methods:** A retrospective longitudinal, observational cohort study of 73 Washington State hospitals for 2010–2015 using data from a standardized state database of hospital abstracts. Abstract records on adult patients (n = 86,378) admitted through the emergency department (ED) from 2010 through 2015 in all tertiary (n = 7) and non-tertiary (n = 66) hospitals in Washington State. **Results:** The overall mortality rate for all hospitals was 6.5%. In the fully adjusted model, the odds ratio for in-hospital death was higher in non-tertiary hospitals compared with tertiary hospitals (odds ratio 1.25; 95% confidence interval 1.17–1.35;  $p < 0.001$ ). **Conclusions:** We observed higher sepsis mortality rates in non-tertiary hospitals, compared with tertiary hospitals. Because most patients who are treated for sepsis are treated outside of tertiary hospitals, and the number of patients treated for sepsis in non-tertiary hospitals seems to be rising, a better understanding of the cause or causes for this differential is crucial. © 2018 Elsevier Inc. All rights reserved.

□ **Keywords—**in-hospital mortality; sepsis; severe sepsis; SIRS; tertiary hospitals; non-tertiary hospitals

#### INTRODUCTION

Sepsis is “a life-threatening organ dysfunction due to a dysregulated host response to infection” (1). More than a million people a year in the United States experience sepsis (or sepsis-related complications), which is the leading cause of in-hospital deaths, and treatment costs are estimated to exceed \$24 billion annually (2–7). Improving the quality of care for sepsis has gained widespread attention for more than a decade. In 2004, the Surviving Sepsis Campaign (SSC) published the first bundled guidelines, which provided a framework for widespread standardization of early treatment and management of sepsis (8,9).

Since the first guidelines were released, studies have consistently reported increases in sepsis awareness and incidence (10). Studies have also reported a decrease in mortality and length of stay, despite the increased incidence of sepsis (8,9,11–13). Most sepsis studies, however, have been conducted in larger urban centers and teaching hospitals (14,15).

Whether patients with sepsis or sepsis-related diagnoses treated in tertiary and non-tertiary hospitals are

achieving comparable benefits is uncertain. Much of the research to date that includes sepsis comparisons, such as that of Villapiano et al. (2017), has made a rural/urban distinction that is not fully comparable with tertiary/non-tertiary (16). Several studies reporting mortality rates between non-tertiary and tertiary hospitals found higher mortality rates for non-tertiary hospitals for conditions with specific treatment guidelines, such as acute myocardial infarction and stroke (17–19).

Sepsis is unique among the leading causes of in-hospital mortality because its diagnosis and treatment, as defined by the SSC, requires neither technology nor other resources that are differentially distributed between tertiary (mostly urban) and non-tertiary (mostly rural) hospitals (9). The diagnosis of sepsis, per guidelines, is by careful clinical observation and common laboratory tests. Treatment is through standard antibiotics and supportive therapies. The purpose of our study was to compare in-hospital mortality among multiple geographically contiguous tertiary and non-tertiary care hospitals in the state of Washington.

## MATERIALS AND METHODS

Our retrospective longitudinal cohort study included 86,378 adult patients aged 18 years or older who were hospitalized with a diagnosis of sepsis between January 2010 and September 2015 in civilian, acute care hospitals in Washington State. The study period terminated with the changeover from International Classification of Diseases, 9<sup>th</sup> Revision (ICD-9) to ICD-10 coding in October 2015. Our project was determined to be exempt from review by the institutional review board at Washington State University (institutional review board exemption #15607).

We utilized de-identified patient data from the Washington State Comprehensive Hospital Abstract Reporting System (CHARS). The CHARS database contains abstracted information on all discharges from civilian hospitals in Washington State. The CHARS database includes data from all payers for hospitalization. The CHARS database does not include information on hospitalizations from federal, Veterans Affairs, or military institutions. Each of the selected hospitals was categorized as a tertiary care or a non-tertiary hospital based on services provided. Tertiary care institutions provide 24-h emergency services and access to all medical and surgical specialty services (20).

### *Inclusion Criteria and Hospitalization Characteristics*

We included in the analysis adult patients (>18 years of age) admitted through the emergency department (ED) and hospitalized in Washington from January 1, 2010

through September 30, 2015. Study participants included patients with an ICD-9-Clinical Modification (CM) primary diagnosis of septicemia (038\*) or systemic inflammatory response syndrome (995.9\*). An ICD-9-CM secondary diagnosis further classified systemic inflammatory response syndrome as not otherwise specified (995.90), sepsis due to infectious process without acute organ dysfunction (995.91), severe sepsis with acute organ dysfunction (995.92), systemic inflammatory response syndrome due to noninfectious process without acute organ dysfunction (995.93), and systemic inflammatory response syndrome due to noninfectious process with acute organ dysfunction (995.94). Study participants were identified as admitted through the ED by the presence of a revenue code of 450–459.

To control for varying severity of illness at entry into the study, we calculated the number of previous hospitalizations within the past 12 months for each participant included in the study. We identified comorbidity variables based on the hospitalization and any other previous hospitalizations (past 12 months) using a set of 30 comprehensive comorbidity definitions employing the Elixhauser method, which allows for the inclusion of 7000 diagnostic codes (ICD-9-CM) that have been categorized into broader diagnosis groupings and assigned to each case according to conditions at hospitalization that worsen patient outcomes (21).

### *Statistical Analysis*

We compared rates of in-hospital mortality in tertiary care hospitals to rates of mortality in non-tertiary care hospitals, and calculated a relative risk for mortality. To examine the risk for mortality between the two cohorts, we used binary logistic regression to control for comorbidities and severity of illness. We calculated the odds ratio (OR) and confidence interval (95% CI) for adjusted and unadjusted hospital mortality for each of the hospitals. After performing unadjusted analyses for both tertiary and non-tertiary centers, we adjusted for potential confounders in the following order: index in-hospital mortality, age, sex, intensive care unit (ICU) admissions, transfers, and comorbidity. Tests were two-tailed, and statistical significance set to 0.05. SPSS software package (Version 20.1; IBM, Armonk, NY) was used for all analyses. The internal validation of main study findings was completed using split-file validation in which the analysis was repeated after cases were randomly assigned to derivation and validation cohorts.

## RESULTS

Among 86,378 adult patients who were hospitalized with sepsis in Washington State hospitals from 2010 through

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