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Adjustment of intensive care unit outcomes for severity of illness and comorbidity scores☆

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Abstract
Purpose: Comparison of outcomes among intensive care units (ICUs) requires adjustment for patient variables. Severity of illness scores are associated with hospital mortality, but administrative databases rarely include the elements of these scores. However, these databases include the elements of comorbidity scores. The purpose of this study was to compare the value of these scores as adjustment variables in statistical models of hospital mortality and hospital and ICU length of stay after adjustment for other covariates.
Materials and Methods: We used multivariable regression to study 1808 patients admitted to a 13-bed medical-surgical ICU in a 400-bed tertiary hospital between December 1998 and August 2003.
Results: For all patients, after adjusting for age, sex, major clinical category, source of admission, and socioeconomic determinants of health, we found that Acute Physiology and Chronic Health Evaluation (APACHE) II and comorbidity scores were significantly associated with hospital mortality and that comorbidity but not APACHE II was significantly associated with hospital length of stay. Separate analysis of hospital survivors and nonsurvivors showed that both APACHE II and comorbidity scores were significantly associated with hospital length of stay and APACHE II score was associated with ICU length of stay.
Conclusion: The value of APACHE II and comorbidity scores as adjustment variables depends on the outcome and population of interest.

1. Introduction

Understanding variation in processes and outcomes of critical care requires analysis of data from large numbers of intensive care units (ICUs). These data are most commonly found in administrative databases. To appropriately compare ICUs that may differ in case mix and severity of illness,

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statistical analysis should include adjustment for these patient-related factors. Although the Acute Physiology and Chronic Health Evaluation (APACHE) II score [1] is one of the most commonly used severity scores in the ICU setting, data found in administrative databases do not usually include the elements of the APACHE II score. However, these databases often include the principal diagnosis and a list of secondary diagnoses, variables required to compute a comorbidity measure [2-4]. A severity of illness score is principally a summary of physiologic derangements within the first 24 hours of admission to ICU, whereas a comorbidity measure is a summary of diagnoses other than the diagnosis most responsible for a hospital admission.

The utility and limitations of severity of illness scores as adjustment variables in statistical models of hospital mortality for critically ill patients are well known [1,5,6]. Although hospital mortality is an important clinical outcome, hospital length of stay and ICU length of stay are other important measures of quality of care. It has been shown that the APACHE II score is strongly associated with hospital mortality for critically ill patients [7], but this score was not developed as an adjustment variable for models of length of stay and does not correlate with this outcome in at least 1 study [8]. This finding may be due to the observation that, for survivors, a higher APACHE II score is associated with a longer length of ICU stay and, for nonsurvivors, a higher APACHE II score is associated with a shorter length of ICU stay.

The Charlson comorbidity index [2] has been used as an adjustment variable in statistical models of long-term mortality in a variety of populations. This index has good interrater reliability [9-11], but accuracy may be limited in elderly survivors of myocardial infarction [12]. This index has also been shown to be a good adjustment variable in models of hospital mortality in critically ill patients and contributes additional prognostic information independent of that obtained from the chronic health points in the APACHE II score [7]. Both of these findings are based on regression analyses that included only severity of illness and comorbidity. However, in models of hospital outcomes, it is important to adjust for other patient-related variables such as age, sex, admitting diagnosis, source of admission, and socioeconomic determinants of health. Furthermore, comorbidity scores have not been tested as adjustment variables in models of length of stay. The comorbidity score developed by D'Hoore and colleagues [13] is a numerical derivation of the Charlson comorbidity index and is based on diagnoses other than the diagnosis most responsible for the hospital admission. In a multivariate analysis of a heterogeneous group of patients, this score was found to be independently associated with hospital mortality [13]. It is not known how strongly this score is associated with hospital mortality and hospital and ICU length of stay in critically ill patients. The purpose of this study was to compare the utility of APACHE II and this comorbidity score as adjustment variables in statistical models of hospital mortality and hospital and ICU length of stay for critically ill patients after adjusting for other patient-related variables.

2. Materials and methods

2.1. Data

The ICU at St Paul's Hospital in Vancouver, Canada, is a 13-bed medical-surgical unit within a 400-bed tertiary-care teaching hospital. There is a separate cardiac surgical ICU and cardiac care unit at this hospital. All of the admissions to the medical-surgical ICU are emergencies; there are no scheduled admissions. We obtained information from the St Paul's Hospital Health Records Department about the hospital encounters of all patients admitted to the ICU between December 1998 and August 2003. The hospital encounter associated with the patient's first ICU admission during the study period was considered the index admission. The fields in this database are entered by a trained health records administrator and include chart encounter number within St Paul's Hospital, unique provincial health-care number for each patient, hospital admission date, hospital discharge date, ICU admission date, the code of *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*), for the most responsible diagnosis (diagnosis associated with the longest length of hospital stay), *ICD-9-CM* codes for up to 15 other diagnoses, and up to 10 *ICD-9-CM* procedure codes. For the same period, the ICU-specific database at St Paul's Hospital, which was populated by specially trained ICU nurses, was used to obtain postal code of patient's residence, age, sex, source of admission, APACHE II score on admission to ICU (collected prospectively), primary ICU admitting diagnosis, hospital mortality, hospital length of stay, and ICU length of stay. Source of admission was categorized into surgical, nonsurgical, emergency, and other hospital, according to the primary service that referred the patient to ICU. This database is an electronic record that automatically acquires demographic data from the hospital admission, discharge, and transfer database. Accuracy of data is improved by automatic alerts for nonsense values and electronic calculation of severity scores after manual input of the elements of these scores. Having 10 different individuals entering data over the 7 years that we have had this database has required intermittent qualitative tests of interrater and intrarater reliability using samples of records; these tests of reliability have always been satisfactory. The 2 databases were linked by provincial health-care number and ICU admission date. We also used the British Columbia Census Tracts database to assign to each individual a median income, percent postsecondary education, and percent unemployment rate for the region in which the patient lived. This socioeconomic information is not subject specific. Based on the code of *International Classification of Diseases, Ninth Revision* (*ICD-9*), of the