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The ICD-10 Charlson Comorbidity Index predicted mortality but not resource utilization following hip fracture

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Abstract

Objectives: To evaluate the performance of the Charlson Comorbidity Index (CCI) in the prediction of mortality, 30-day readmission, and length of stay (LOS) in a hip fracture population using algorithms designed for use in International Classification of Diseases, 10th Revision (ICD-10)–coded administrative data sets.

Study Design and Setting: Hospitalization and death data for 47,698 New South Wales residents aged 65 years and over, admitted for hip fracture, were linked. Comorbidities were ascertained using ICD-10 coding algorithms developed by Sundararajan (2004) and Quan (2005). Regression models were fitted, and area under the receiver operating curve (AUC) and Akaike information criterion were assessed.

Results: Both algorithms had acceptable discrimination in predicting in-hospital (AUC, 0.72–0.76), 30-day (0.72–0.75), and 1-year mortality (0.69–0.75) but poor ability to predict 30-day readmission (0.54–0.57) or LOS (adjusted R^2, 0.007–0.045). The Quan algorithm provided better model fit than the Sundararajan algorithm. Models incorporating comorbidities as individual variables performed better than the Charlson weighted or updated Quan weighted score. Including a 1-year lookback period increased predictive ability for 1-year mortality only.

Conclusion: The CCI is a valid tool for predicting mortality but not resource utilization after hip fracture. We recommend the use of the Quan algorithm rather than Sundararajan algorithm and to model individual conditions rather than categorized weighted scores.

Keywords: Comorbidity; Charlson Comorbidity Index; ICD-10; Risk adjustment; Mortality; Hip fracture

1. Introduction

Comorbidity plays an important role in both the occurrence and outcome of a health event and is of particular importance when evaluating performance within and between hospitals and health care services. Among the available and validated comorbidity measures, the Charlson Comorbidity Index (CCI) has been the most widely adopted [1]. The CCI was originally developed in a relatively small inception cohort of 559 patients admitted to the medical services of one hospital in New York in 1984 and used to predict 1-year all-cause mortality and then validated in a cohort of breast cancer patients [2]. The CCI score was derived from the sum of 19 conditions, which were selected based on the relative risk of 1-year mortality in the inception cohort and assigned a score between 1 and 6 based on the mortality risk. Subsequent studies have shown the CCI to be a reliable predictor of mortality for a variety of conditions including cancer [3,4], stroke [5], diabetes [6], coronary artery bypass grafting [6], and chronic renal failure [6]. Although not originally developed for prediction of resource use, the CCI has also been shown to correlate with measures of morbidity including disability, readmission, and length of stay (LOS) [5,7]. Validation of its utility in risk adjustment for resource use is required.

Coding algorithms to identify comorbidities in large administrative data sets have been developed for use with the International Classification of Diseases, Ninth Revision (ICD-9) [8–10] and more recently, 10th Revision (ICD-10) [11,12] coded data. Two ICD-10 coding algorithms, the Sundararajan version [11] and the Quan version [12], have been extensively used in the literature. The 2004 Sundararajan coding algorithm was developed by a two-step process; the ICD-9 codes used in the Deyo coding algorithm [8] were mapped to ICD-10 codes, and the resultant codes were then reviewed for face validity by coding experts and a general physician [11]. In 2005, Quan enhanced the

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What is new?

Key findings

- The Charlson Comorbidity Index is a valid tool for predicting mortality but not length of stay or 30-day readmission after hip fracture using ICD-10 coded administrative data.

What this adds to what was known?

- The Quan coding algorithm provided better model fit than the Sundararajan algorithm. Models incorporating comorbidities as individual variables performed better than the Charlson weighted or updated Quan weighted score. Including a 1-year lookback period increased predictive ability for 1-year mortality only.

What is the implication and what should change now?

- For older populations, we recommend the use of the Quan algorithm rather than Sundararajan algorithm and to model individual conditions rather than categorized weighted scores.

ICD-10 coding algorithm by reviewing existing algorithms and incorporating additional codes recommended by a panel of clinicians and professional coders [12]. More recently, Quan et al. have updated the weighting system associated with their index to include only 12 of the original comorbidities reweighted to reflect changes in disease prevalence, management, and outcomes since the introduction of the original CCI, and have shown it to have good predictive ability using ICD-10 coded administrative data from six countries, including Australia [1].

Although the CCI has been shown to be a good tool for nontrauma conditions and the general population (all hospitalizations), its utility for predicting mortality in trauma populations is less clear. It has been shown to be a useful predictor of 30-day mortality in trauma patients admitted to the emergency department [13] but not to be a good predictor of in-hospital mortality [14,15], 1-year mortality [16], and disability [17]. The limited predictive power may stem from the nature of the trauma population from which these studies were drawn, as trauma patients tend to be younger and may not have a high number of comorbidities. The few studies that have assessed the performance specifically in an older hip fracture population found the CCI to be a useful predictor of in-hospital [18] and 30-day mortality [19] but not of 90-day mortality [20]. However, these studies were undertaken using chart review or ICD-9 coded data, and to our knowledge, no study has assessed the predictive ability of the CCI for hip fracture risk adjustment in large ICD-10 coded administrative data sets.

Our aims were as follows: first, to assess the performance of the CCI in an older hip fracture population in prediction of in-hospital mortality, 30-day mortality, 1-year mortality, 30-day all-cause readmission, and LOS and second, to determine which of the ICD-10 coding algorithms (Sundararajan or Quan) perform better in this high-volume, high-cost population whose numbers continue to grow annually.

2. Methods

2.1. Study population and data sources

New South Wales (NSW) is Australia's most populous state with a population of more than 7.3 million people, 1.1 million of whom are aged 65 years and over [21]. The study population comprised NSW residents aged 65 years and over admitted to an NSW hospital with a hip fracture between July 1, 2001, and June 30, 2010.

Two data sets were used in this study: the NSW Admitted Patient Data Collection (APDC) and the NSW Register of Births, Deaths and Marriages (RBDM). The APDC is an administrative data set that records hospitalizations for all public and private hospitals in NSW. It includes data on "episodes of care" in hospital, which end with the discharge, transfer, or death of the patient or when the service category for the admitted patient changes (eg, a change from acute care to rehabilitation for a patient during one episode of care in a single facility). Data are coded using the International Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification (ICD-10-AM) [22]. The RBDM data set contains records of all deaths of NSW residents, certified by either a registered medical practitioner or the state coroner at the conclusion of an inquiry into the circumstances of the death.

2.2. Data linkage

Linkage of extracts from hospitalization and death registration records was undertaken by the Centre for Health Record Linkage (CHeReL). Data linkage by the CHeReL uses probabilistic matching of patients' names, date of birth, and address with ChoiceMaker software [23], supplemented with clerical review of uncertain matches. The false-positive and false-negative rates for APDC and RBDM linkage are 0.3% and 0.5%, respectively [24].

2.3. Case inclusion criteria

Hip fracture cases were identified using a primary diagnosis code of hip fracture (ICD-10-AM S72.0, S72.1, and S72.2), as recommended by the Australian Institute of Health and Welfare [25]. The index admission was assigned as the first hip fracture admission for each patient