



# The evaluation of three comorbidity indices in predicting postoperative complications and readmissions in pediatric urology

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## Summary

### Introduction

The surgical comorbidity assessment is important for patient risk stratification, counseling, and research. In adults, risk assessment indices, such as the Charlson Comorbidity Score (CCS) or Van Walraven Index (VWI), are well established. In pediatrics, however, risk assessment indices are scarce. Recently, a pediatric-specific risk assessment index, the Rhee index, was developed to discriminate mortality for pediatric general surgery patients. Currently, there is no validated risk assessment tool in pediatric urology.

### Objective

We compared the performance of the CCS, VWI, and Rhee Index in discriminating postoperative complications and readmissions to the emergency room/inpatient unit after pediatric urological procedures.

### Methods

We analyzed the Nationwide Readmissions Database (NRD), State Inpatient Databases (SID), and State Emergency Department Databases (SEDD). We included patients (<18 years) who underwent the following urological procedures: ureteroneocystostomy, ureteroureterostomy, radical/partial nephrectomy, pyeloplasty, appendicovesicostomy, enterocystoplasty, vesicostomy, and bladder neck sling. Complications were identified based on definitions in the National Surgical Quality Improvement Program (NSQIP). Thirty-day emergency room admission and inpatient readmissions were extracted. Comorbidity scores were calculated using each of the three indices. We compared the performance of each index in discriminating primarily postoperative complications in the NRD

and both admission types in the SID/SEDD by constructing a receiver operating characteristics (ROC). AUCs were compared using the Delong method.

This protocol was reviewed by our Institutional Review Board and deemed to be exempt.

### Results

We identified a total of 8006 patients in NRD and 6236 patients in SID/SEDD. The Rhee index had the best performance for discriminating postoperative complications (AUC = 0.67, 95% CI 0.64–0.70) compared to CCS (AUC = 0.62, 95% CI 0.60–0.65) and VWI (AUC = 0.62, 95% CI 0.59–0.65);  $p < 0.01$ . The CCS had the best performance for discriminating 30-day inpatient readmissions (AUC = 0.63, 95% CI 0.61–0.66) than VWI (AUC = 0.54, 95% CI 0.52–0.57), and Rhee Index (AUC = 0.56, 95% CI 0.54–0.59);  $p < 0.0001$ . All three indices had similarly poor discrimination for 30-day ER admissions: CCS (AUC = 0.52), VWI (AUC = 0.51), and Rhee Index (AUC = 0.50);  $p = 0.5$  (see Table).

### Discussion

The Rhee Index had the best performance for discriminating postoperative complications, while the CCS was superior for discriminating inpatient readmissions among the three indices. Limitations to our study include inpatient-only procedures, inability to identify complications managed in clinics, omission of secondary operations, accounting for parental anxiety, and the generalizability of SID.

### Conclusions

The three comorbidity indices evaluated are poor discriminators for postoperative complications, 30-day inpatient readmissions or 30-day ER admissions. A new index is needed for pediatric urology patients.

**Table** Results summary.

	30-day inpatient readmission	30-day ER admission	Postoperative complication
CCS	AUC = 0.63 (95% CI 0.61–0.66)	AUC = 0.52 (95% CI 0.50–0.54)	AUC = 0.62 (95% CI 0.58–0.66)
VWI	AUC = 0.54 (95% CI 0.52–0.56)	AUC = 0.51 (95% CI 0.49–0.53)	AUC = 0.61 (95% CI 0.58–0.65)
Rhee	AUC = 0.56 (95% CI 0.53–0.58)	AUC = 0.50 (95% CI 0.48–0.52)	AUC = 0.67 (95% CI 0.63–0.71)
Comparison	$p < 0.001^*$	$p < 0.4^*$	$p < 0.05^{**}$

The  $p$ -value represents the larger  $p$ -value between the two comorbidity scores compared with the reference score.

\* Charlson Comorbidity Score was used as the reference group.

\*\* Rhee was used as the reference group.

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## Introduction

Surgical comorbidity assessment is an integral part of patient risk stratification, counseling, and clinical research. Patient-related comorbidities can impact surgical mortality, post-surgical complications, and readmissions and, thus, influence healthcare outcome and cost [1]. It is imperative to identify at-risk patients preoperatively to provide additional counseling and care to ensure the best surgical outcome.

Among adults, comorbidity assessment is well established. The Charlson Comorbidity Score (CCS) and Van Walraven Index (VWI) are two commonly used risk assessment scores designed to discriminate mortality with good validity and reliability [2]. The CCS has been validated in clinical practice, and its modification by Romano et al. has been used extensively in administrative database research [3]. The VWI is specifically designed for administrative database use, and it is a modification of the Elixhauser score. Previous studies comparing CCS and VWI in the administrative setting found VWI to be slightly superior to CCS in discriminating both mortality and readmission [4]. By contrast, validated comorbidity indices in pediatrics are scarce. Since the majority of children do not require long-term care and mortality is rare, pediatric risk assessments have been limited to acute care settings using physiologic parameters to discriminate impending in-hospital mortality of severely ill patients [5].

Recently, Rhee et al. [6] developed a pediatric-specific multispecialty risk index using 70 medical comorbidities to discriminate mortality in mostly general surgery patients with reported receiver operating characteristics (ROC) of 0.90. However, using mortality as an outcome discriminator may not be useful for pediatric urology patients given the exceedingly low perioperative mortality rates, and, thus, a more clinically relevant end point would be complications and readmissions.

Currently, there is no validated risk assessment index specifically for pediatric urology. Therefore, we aimed to determine if the CCS, VWI, and Rhee index could be extended beyond their designed purpose to discriminate postoperative complications and readmissions after urological procedures. We hypothesized that the Rhee index would have better performance for all outcomes than VWI and CCS.

## Methods

### Data sources

We used a compilation of several data sources in order to examine outcomes occurring in both inpatient and emergency settings. Specifically, we used data from the Healthcare Cost and Utilization Project (HCUP): the 2013 Nationwide Readmissions Database (NRD) and 2007–2010 State Inpatient Databases (SID) and State Emergency Department Database (SEDD) from California, Florida, North Carolina, New York, and Utah were selected to provide a broad geographic overview.

NRD is specifically designed to track inpatient readmissions. It includes 21 states that are geographically

dispersed and account for 49% of all US hospitalizations [7]. However, the NRD cannot link to emergency room visits.

SID includes annual, state-specific inpatient data. SEDD is an annual, encounter-level data on emergency department (ED) visits to hospital-affiliated emergency departments that do not result in admissions. Using HCUP supplemental variables for revisit analysis, SID and SEDD can be linked to track sequential visits in the ER within a given timeframe.

Since the NRD cannot link emergency room visits, we primarily evaluated how well each index can discriminate postoperative complications and modeled 30-day inpatient readmission as a secondary analysis in the NRD. To model 30-day inpatient and ED admissions, we used SID and SEDD as these two databases can be linked to track a specific patient within and across the two settings. Per HCUP requirements, we limited reporting of any events occurring in a minimum of 15 patients in either database.

### Comorbidity indices

#### Charlson Comorbidity Index

The CCS includes 17 disease conditions that are weighted based on their relative severity. A summary score is calculated based on the sum of the weights [8]. The CCS can be adopted for administrative database research by using the Enhanced ICD-9-CM diagnosis codes listed in Quan et al. [9].

#### Van Walraven Index

The VWI is a modification of the Elixhauser comorbidity score [10]. The Elixhauser score includes 30 dichotomous disease variables instead of an overall index score. To overcome this limitation, Van Walraven et al. [11] derived weights to summarize the 30 variables into a single score. The possibility of having a *negative* comorbidity score in VWI should be emphasized. As previously explained by Elixhauser et al. [10] this is mainly a coding bias inherent to administrative database. For example, severely ill patients have so many diagnoses that the more “benign” conditions are overlooked and not coded. Conversely, a healthy patient is more likely to have a benign diagnosis coded in the absence of other more serious conditions. Thus, the presence of codes for non-threatening diseases is a proxy for healthy patients and associated with a decreased risk of in-hospital death.

#### Rhee index

The Rhee Index is a pediatric specific risk assessment tool designed to discriminate mortality for mostly general surgery patients. The index consists of a 7-point scale developed using 70 comorbid variables. It has an excellent reported AUC of 0.90 for discriminating mortality after pediatric surgery [6].

#### Cohort selection

We included patients less than 18 years of age who underwent inpatient urology specific procedures identified by International Classification of Diseases, 9th revision, Clinical

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