Modifying the Charlson Comorbidity Index for the American Indian Population Using The Strong Heart Study Data

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Objective

The Charlson Comorbidity Index (CCI) is a frequently used mortality predictor based on a scoring system for the number and type of patient comorbidities health researchers have used since the late 1980s. The CCI may not accurately reflect risk among the American Indian population because they are a small proportion of the U.S. population and possibly lack representation in the original patient cohort. A motivating factor in understanding if the CCI is a valid prediction tool calibrating a CCI for the American Indian population is that they, as a whole, experience a greater burden of comorbidities, including diabetes mellitus, obesity, cancer, cardiovascular disease, and other chronic health conditions, than the rest of the U.S. population. This study attempted to modify the CCI to be specific to the American Indian population (which we labeled "modified CCI for American Indian" or mCCI-AI), utilizing the data from the still ongoing The Strong Heart Study (SHS) - a multi-center population-based longitudinal study of cardiovascular disease among the American Indian population.

We hypothesize that mCCI-AI would be a better predictor of mortality in American Indian population than the original CCI.

Methods

The total of 3,038 Phase VI participants from SHS comprise the study population for whom mortality and morbidity surveillance data were available through December 2019.

A one-year survival analysis with mortality as the outcome was performed using the SHS morbidity and mortality surveillance data and assessing the impact of comorbidities in terms of hazard ratios with the training cohort. Last, a Kaplan-Meier plot for a subset of the training cohort was used to compare groups with mCCI-AI scores of zero, three, and six.

Sixty percent of the study sample was randomly allocated to the training cohort, while the remaining 40% was assigned to the testing cohort. The purpose of the training cohort was to generate the hazard ratios used for calculating the modified CCI for the American Indian population (mCCI-AI) scores with a Cox-Proportional Hazards model. Weights were based on the magnitude of the hazard ratios (HR): conditions with a hazard ratio $1.2 \leq HR < 1.5$ were assigned a weight of 1; those with a hazard ratio $1.5 \leq HR < 2.5$ a weight of 2; conditions with a hazard ratio $2.5 \leq HR < 3.5$ a weight of 3; and those with a hazard ratio greater than six were assigned a weight of 6.

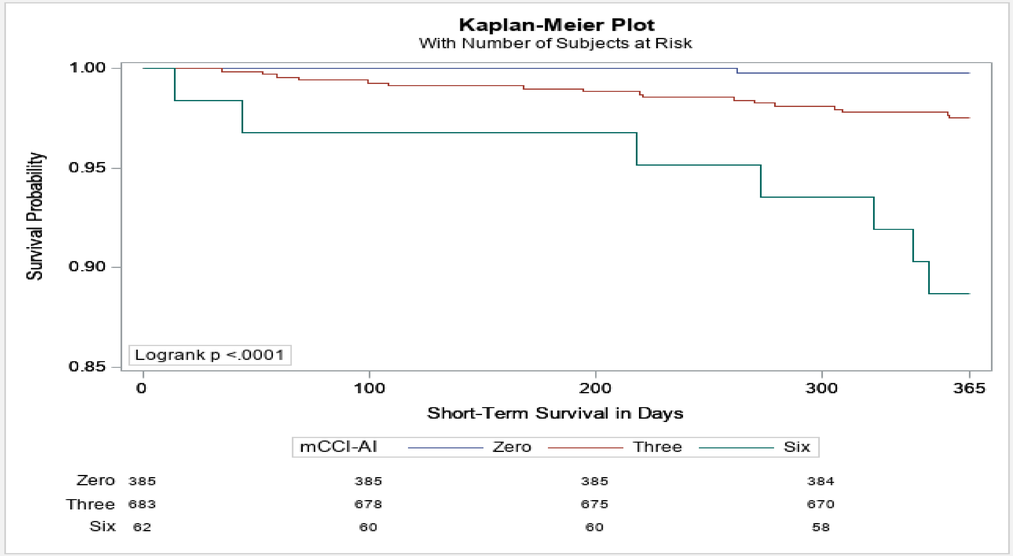
Upon completion, each individual in the testing cohort received both an mCCI-AI score based on the results from the training cohort and a CCI score based on the traditional weights. These two scores were then compared regarding their ability to predict one-year mortality.

Results

Table 1. Cox Proportional Hazards model results for statistically significant (alpha = 0.10) factors for short-term mortality with the original CCI weights for comparison.

Variable	Original CCI Weight	MCCI-AI Weight	Hazard Ratio
Myocardial Infarction	1	2	1.996
Congestive Heart Failure	1	3	2.906
Liver Disease	1 or 3 (mild/severe)	3	3.405
Lung Cancer	6 (metastatic solid tumor)	6	8.308
High Blood Pressure	0	3	2.785

Figure 1. Kaplan-Meier plot of short-term mortality for subjects with mCCI-AI scores of zero, three, and six. The logrank test compared the three groups representing different risk strata.



Discussion

This study found that myocardial infarction, congestive heart failure, liver disease, high blood pressure, and lung cancer were significant predictors of one-year mortality in the American Indian population. Myocardial infarction, congestive heart failure, and high blood pressure were weighted higher in our study than in Charlson's original study.

Harrell's concordance statistic indicated that the mCCI-AI was able to distinguish between participants that died and survived 73% of the time while the CCI only achieved 66% discriminatory power.

The observed differences between the original CCI and the mCCI-AI may be due to a real difference in the health of the American Indian population from those of other racial and ethnic populations and the overall U.S. population.

Conclusion

This study found that the mCCI-AI was a statistically significant and better predictor of mortality than the original CCI. This was confirmed by the Kaplan-Meier plot for groups of SHS participants that were assigned mCCI-AI scores of zero, three, and six. A tool such as the mCCI-AI allows a more accurate assessment of American Indian subjects relative to one- year mortality than could be provided by the original CCI.

Limitations

The SHS study included data on multiple diseases and conditions, some of which were not included in Charlson's original study. Two of the included conditions, stroke, and peripheral arterial disease, failed the proportional hazards assumption and were excluded from this study. The SHS data set did not include individuals from every tribe, so the mCCI-AI may not be representative of the total American Indian population.

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