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The Charlson Comorbidity Index as a Predictor of mortality in hospitalized Covid-19 patients during the pandemic

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A B S T R A C T

Introduction: This study aimed to predict the risk of mortality among COVID-19 patients in the central region of Iran by employing the Charlson Comorbidity Index (CCI), with adjustments made for age in the predictive model.

Material & Methods: In this cross-sectional study, encompassing all probable, suspicious, and confirmed COVID-19 cases from the onset of the pandemic (55307 individuals), 3415 cases resulting in death were designated as the study group, while the survivors constituted the control group.

Results: The Charlson Comorbidity Index revealed that over 11 percent of all patients had at least one underlying medical condition. Logistic regression analysis indicated a significantly elevated likelihood of mortality among patients with comorbidities. Specifically, individuals with a CCI score of 6 or higher were more than twice as likely to succumb to the virus compared to those without underlying diseases. Those with a score of 6 or more exhibited the highest odds ratio (OR 2.4; 95% CI 1.3-4.5).

Conclusion: The study findings underscore the heightened vulnerability of individuals to COVID-19 mortality, particularly among the elderly with pre-existing health conditions. The coexistence of age and comorbidities substantially increased the risk of death due to COVID-19 in this population. Consequently, targeted interventions and focused care strategies may be crucial for this high-risk demographic in pandemic management efforts.

Keywords: Mortality, Prediction, Infection, Charlson Comorbidity Index

➢ **How to cite this paper**

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Introduction

Two years into the COVID-19 pandemic, global infection rates exceeded 400 million, resulting in over 575,000 fatalities (1, 2). Notably, individuals with pre-existing health conditions, including liver diseases, kidney diseases, cardiovascular diseases, and cancers, faced a heightened risk of mortality.

A comparative analysis of mortality rates across 25 European countries revealed substantial variability, ranging from 5 (in Bulgaria) to 385 deaths per 1 million populations (in Spain). Among the contributing factors, the proportion of individuals aged 65 years and older exhibited considerable diversity among these nations (3).

An international multicenter study delving into COVID-19 mortality risk factors highlighted significant associations between heart diseases, diabetes, and increased mortality rates. The study reported a 2 percent higher prevalence of heart diseases and a 4 percent higher prevalence of diabetes among deceased patients compared to survivors. Additionally, respiratory disorders emerged as a critical risk factor, with COVID-19 patients possessing such disorders experiencing an odds of death more than three times higher than their counterparts (4,5).

Cumulatively, comorbidities played a pivotal role in elevating the risk of death in COVID-19 patients. Studies indicated that individuals with Diabetes Mellitus faced a threefold higher likelihood of mortality. Furthermore, patients with cardiovascular diseases and kidney diseases exhibited a two- and five-times higher risk of death, respectively (6,7).

To quantify the impact of comorbidities on mortality, indices such as the Charlson Comorbidity Index (CCI) were employed. The CCI serves as a valuable tool to assess how underlying diseases influence the probability of death. In the present study, conducted in the central region of Iran, the CCI was utilized to predict the risk of death among COVID-19 patients, with age adjustments incorporated into the predictive model. This approach aimed to provide a comprehensive understanding of the interplay between comorbidities, age, and mortality in the context of COVID-19.

Materials and Methods

Data Accessing

All patients referred to COVID-19 diagnostic centers are registered in a registry called the Medical Care Monitoring Center (MCMC). Based on clinical symptoms, contact history, and PCR test results, patients are categorized into three groups: suspected, probable, and confirmed cases. Demographic information and details about underlying diseases, including cardiovascular, respiratory, dementia, cancers, diabetes, liver disease, and AIDS, are recorded using ICD-10 codes. Access to this data was facilitated through coordination with the MCMC.

Study Design

In this cross-sectional study, all probable, suspicious, and confirmed cases (55307 people) from the onset of the pandemic were incorporated, with a total of 3415 individuals having succumbed. The

analysis encompassed the entirety of the cases, ensuring a comprehensive examination of the dataset.

Charlson Comorbidity Index

The Charlson Comorbidity Index (CCI) serves as a metric assessing the one-year risk of mortality by assigning weights to patients based on their underlying diseases. These weights are intricately calibrated, varying in severity across different medical conditions. For instance, conditions such as Myocardial infarction, Congestive heart failure, Peripheral vascular diseases, Cerebrovascular diseases, Dementia, Chronic pulmonary disease, Connective tissue disease, Ulcer disease, Mild liver disease, Diabetes, Depression, Use of warfarin, and Hypertension carry a weight of 1. Conditions such as Hemiplegia, Moderate or severe renal disease, Diabetes with end-organ damage, Any tumor, Leukemia, Lymphoma, and Skin ulcers/cellulitis are weighted 2. Moderate or severe liver disease is assigned a weight of 3. The most severe conditions, Metastatic cancer, and AIDS, bear their unique weightings (8, 9).

Data Analysis

After data cleaning and preparation, the frequency of each CCI score (0 to 6 and higher) was calculated. Finally, utilizing logistic regression, the effect of each CCI score level on the likelihood of death due to COVID-19 was computed while adjusting for age.

Results

The mean and standard deviation of age were 69.3±17.8 and 51.6±20.4 for cases and controls, respectively. As per the CCI, over 11 percent of all patients exhibited at least one underlying disease. Specific weights were assigned to each comorbidity, with AIDS and chronic pulmonary disease holding the highest and lowest weights, respectively, as outlined in Table 1. Furthermore, more than 11% of all patients presented with multiple comorbidities.

Logistic regression modeling indicated that nearly all patients with comorbidities faced an elevated risk of mortality. Those with a CCI score of 6 or higher were more than twice as likely to die compared to those without any underlying diseases.

Table 1. Charlson Comorbidity Index Score with Associated Comorbidity Weight and Frequency of Occurrence in the Study Population

Comorbid Conditions	Charlson Comorbidity Weight	Number of Patients (%)
Coronary artery disease	1	2196 (4)
Chronic pulmonary disease	1	261 (0.4)
Dementia	1	239 (0.4)
Diabetes mellitus with end organ damage	2	3002 (5.4)
Any tumor within 5 years	2	393 (0.7)

Moderate to severe renal disease	2	434 (0.7)
Moderate to severe liver disease	3	53 (0.1)
AIDS	6	13 (0.02)

Table 2. Multivariate Analysis to Predict COVID-19 Mortality in Comorbidity Patients

Weight	Died patients (%)	Alive patients (%)	Odds Ratio (95% CI)*	P-Value
0	167 (4.9)	14087(27.3)	1	-
1	149 (4.3)	7793 (15.2)	1.4 (1.2-1.6)	P <0.001
2	263 (7.7)	7578 (14.7)	1.6(1.4-1.9)	P <0.001
3	490 (14.4)	7083 (13.7)	1.9(1.6-2.2)	P <0.001
4	1223 (35.8)	8582 (16.6)	1.7(1.3-2.1)	P <0.001
5	455 (13.3)	3266 (6.3)	2.2(1.6-3.1)	P <0.001
6 or more	668 (19.6)	3233 (6.2)	2.4(1.3-4.5)	P <0.001

*Adjusted by Age

Discussion

The findings of this study underscore a significant correlation between Charlson Comorbidity Index (CCI) scores and the likelihood of death among COVID-19 patients. Notably, individuals with a CCI score of 6 or higher exhibit an elevated risk, being up to 2.5 times more prone to mortality compared to those with a score of zero.

CCI has been extensively employed in diverse studies, each revealing its utility in predicting outcomes across various medical contexts. For instance, research involving liver transplant recipients indicated that those with high CCI scores had diminished chances of survival (9). Similarly, investigations into hospitalized patients with acute coronary syndrome demonstrated an increased probability of death among those with 3 or more CCI scores (10).

In the context of suspected infections, CCI has been employed to calculate one-year mortality. Results indicate that patients with a CCI score of 5 or more face a hazard ratio of 4.7, highlighting a nearly fivefold increased risk of death compared to those without comorbidities (11).

The application of CCI as a predictor extends to the elderly population, where individuals with higher CCI scores exhibit twofold higher odds of death (12).

Different underlying diseases contribute to varying risks of death. Studies reveal a threefold increased chance of death among COVID-19 patients with diabetes and a twofold increased risk for those with kidney diseases. The collective evidence suggests that the presence of COVID-19 alongside underlying diseases escalates the risk of mortality (13, 14).

CCI, as a survival probability index, effectively captures the nuanced relationship between comorbidities and mortality. In this study, an ascending weight score in the CCI aligns with an augmented chance of death. This observation resonates with other studies, including those focused on hospitalized patients, which consistently demonstrate a positive correlation between higher CCI values and increased mortality risk (4).

In the context of patients with a surgical history, those concurrently harboring additional underlying diseases, particularly with a CCI score of 6 or higher, face a tripled risk of mortality (5).

Conclusion

This study strategically employs CCI as a tool to control for comorbidities. The results highlight those individuals with both advanced age and at least one underlying disease experienced the highest number of deaths due to COVID-19. Consequently, the presence of comorbidities appears to substantially amplify the risk of death in this population.

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Conflict of Interests

The authors declare no conflicts of interest.

Authors' Contributions

All authors participated in all parts of the study.

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