The Use of Charlson Comorbidity Index for Patients Revisiting the Emergency Department within 72 Hours

Han-Yi Wang, MD; Ghee Chew, MD; Chia-Te Kung, MD; Kun-Jung Chung, MD; Wen-Huei Lee, MD

Background: To validate the use of the Charlson Comorbidity Index (CCI) for predicting admission of patients revisiting the Emergency Department (ED) within 72 hours.

Methods: Non-trauma patients aged above 17 years old who revisited an urban ED within 72 hours during January of 2004 were included in this retrospective observational study. Demographic data, diagnosis, CCI, in-hospital mortality rate and length of hospital stay were reviewed, and comparisons were made between the patients who were admitted or discharged on their return visits.

Results: Of the 168 enrolled patients, 60 were admitted to a ward and 108 were discharged. Revisiting patients with high CCIs (≥ 2) had a higher admission rate (67.3% vs. 22.7%; $p < 0.001$) and an increased adjusted odds ratio of admission (odds ratio (OR) 2.06; 95% confidence interval (CI) 1.14-3.75) than low CCI patients. Admitted revisiting patients with high CCIs had poorer prognoses, longer hospital stays (11.79 ± 8.92 days vs. 6.78 ± 5.17 days; $p < 0.05$) and a higher in-hospital mortality rate (15.2% vs. 3.7%; $p = 0.209$).

Conclusion: CCI was well correlated with the admission possibility of patients revisiting the ED within 72 hours. More clinical management and discharge strategies should target those revisiting patients who have more comorbidities.

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Key words: Charlson Comorbidity Index, emergency department, revisit

The review of unexpected returns to the Emergency Department (ED) is a powerful tool for quality assurance and improvement of patient care.[1-3] Most unscheduled returns are a result of illness- and patient-related factors rather than medical errors, and only one-third of these cases are avoidable.[3,4] The reasons for these returns have undergone the greatest analysis. High-risk patients are also prone to unscheduled returns. As such, identifying risk factors, such as certain diagnosis groups, chief complaints and demographic factors,[5-7] is the next target for prospective prevention strategies to minimize unscheduled returns.

Unscheduled hospital re-admissions are a critical indicator of the severity of a patient's condition. Such patients are also potential sources of medical and legal problems arising from medical errors or patient dissatisfaction. Thus, admissions of patients revisiting the ED within 72 hours could be an important target to improve discharge decisions and the

From the Department of Emergency Medicine, Chang Gung Memorial Hospital-Kaohsiung Medical Center, Chang Gung University College of Medicine, Kaohsiung, Taiwan.
Received: Jun. 2, 2006; Accepted: Feb. 8, 2007
Correspondence to: Dr. Wen-Huei Lee, Department of Emergency Medicine, Chang Gung Memorial Hospital. 123, Dapi Rd., Niaosong Township, Kaohsiung County 833, Taiwan (R.O.C.) Tel.: 886-7-7317123 ext. 8415; Fax: 886-7-7317123 ext. 8787; E-mail: Malee4950@cgmh.org.tw

quality of patient care. Few studies have focused on this group. One study on admissions of patients revisiting the ED within 72 hours identified patients older than 65 years and elderly patients with insurance as risk factors.[8] Is comorbidity a prognostic factor for the admission of revisiting patients? This is the question we have tried to answer.

The Charlson Comorbidity Index (CCI) is a scoring system that includes weighting factors on the basis of disease severity. The system was developed, originally, as a prognostic indicator for patients with a variety of medical conditions who were admitted to a general medical service, and was then validated in an independent cohort of women with breast cancer.[9] Since it was first published, the CCI has been commonly used to measure patients' comorbid conditions. The aim of this study is to use the CCI to measure the comorbid conditions of patients revising the ED within 72 hours in order to evaluate its validity as a prognostic indicator for admission.

METHODS

This retrospective observation study was conducted at a tertiary referral medical center, which is situated in the urban area of Kaohsiung, the second largest city in Taiwan. The medical center is a 1,700-bed private teaching hospital with approximately 60,000 annual adult non-trauma visits to the ED. All adult non-trauma patients who were discharged from the ED and revisited within 72 hours during the whole month of January 2004 were included in the study.

All revisits within 72 hours were noted by the ED computer information system as part of a quality control surveillance program. ED physicians were alerted and compulsorily required to input the reasons for the revisit when they accessed the computer on the patients' return visit. The reasons for the revisit were classified into 5 categories, including new problem, disease-related factors, patient-related factors, physician-related factors and other. ED physicians admit or discharge patients on their return visit according to individual clinical decisions. An Outpatient Department appointment is arranged if necessary and is followed by a telephone call between 3 to 5 days after the patient was discharged on their return visit. The exclusion criteria included those who left the ED against medical advice, cases in which the first and second visits were determined to be due to a new problem, and patients who were lost to follow up after the second visit.

Enrolled patients were divided into admission and discharge groups. The admission group was composed of patients who returned within 72 hours and were admitted to hospital. The discharge group, as the control group, was composed of revisiting patients who were discharged from the ED during the study period. The medical charts were reviewed to record the patients' age, gender, initial diagnosis, length of hospital stay, in-hospital mortality and CCI. These demographic data, clinical characteristics and CCI score were compared between the admission group and discharge group.

The present disease nomenclature based on the ICD-9-CM is not a good indicator of disease severity. A weight was assigned in each indicated diagnosis and added together to provide a total CCI score. A disease with different severities was classified in different categories. For instance, diabetes was weighted as 1 but diabetes with end-organ damage was weighted as 2. Myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular accident, dementia, chronic pulmonary disease, connective tissue disease, gastrointestinal ulcer disease, mild liver disease and diabetes mellitus were all weighted 1 (Table 1). Hemiplegia, moderate to severe renal disease, diabetes with end-organ damage, tumor of any type, leukemia and lymphoma were weighted 2. Moderate to severe renal disease was weighted 3. Autoimmune deficiency syndrome and metastatic solid tumor were weighted 6. A weight of 1 or 0 was classified as low comorbidity and a weight of 2 and more was classified as high comorbidity.

Analysis was performed with SPSS software (version 11.5, SPSS Inc., Chicago, IL, USA). Distribution of age, gender, initial diagnosis and CCI score between the admission and the discharge groups were analyzed to identify significant associations between these clinical characteristics. Statistical tests were used to compare variables between two study groups including chi-square test for dichotomous variables and *t*-tests for normally distributed continuous variables. To derive the correlation of admission possibility with confounding factors, binary logistic regression analysis was used. In addition to gender and age comparisons between

Table 1. Charlson Comorbidity Index

Assigned weights for disease	Disease
1	Myocardial infarction
	Congestive heart failure
	Peripheral vascular disease
	Cerebrovascular accident
	Dementia
	Chronic pulmonary disease
	Connective tissue disease
	Gastrointestinal ulcer disease
	Mild liver disease
	Diabetes mellitus
2	Hemiplegia
	Moderate to severe renal disease
	Diabetes with end-organ damage
	Any tumor
	Leukemia
	Lymphoma
3	Moderate or severe liver disease
6	Autoimmune deficiency syndrome
	Metastatic solid tumor

From "A new method of classifying prognostic cormorbidity in longitudinal studies: development and validation," by Charlson ME, Pompei P, Ales KL, MacKenzie CR, 1987, J Chronic Dis, 40, p377. Copyright 1987 by Pergamon Journals Ltd.

high and low comorbidity groups of revisiting patients, length of hospital stay and in-hospital mortality rate were compared for admitted revisiting patients using the same statistical procedures. Binary logistic regression was also used for adjusting potential confounding factors.

RESULTS

During the study period, 6,282 patients visited the ED and a total of 183 patients revisited within 72 hours. Thirteen patients were excluded based on the exclusion criteria. Sixty-two patients returned and were admitted to the ED after 72 hours of discharge. Two of them were excluded due to missing admission records. Thus, sixty patients were enrolled as the admission (study) group and the other 108 discharged revisiting patients were enrolled as the discharge (control) group. All patients in the discharge group were followed up by telephone calls, and it was confirmed that they were stable and had not been admitted to other hospitals.

The characteristics and demography of the admission and discharge groups are shown in Table 2. The mean age of the admitted patients was higher than that of the discharged patients (58.53 $\pm$ 15.27 years vs. 44.87 $\pm$ 18.10 years, $p < 0.001$). Older patients (> 66 years) had a more than fourfold increased odds ratio of admission compared to younger patients (aged between 18-30 years, OR 4.40; 95% confidence interval (CI) 1.14-16.95). Among the admitted patients, the most frequent initial diagnosis was digestive problems (31.7%), followed by malignancy-related conditions (23.3%). Digestion-related problems were also the main diagnosis for the discharge group, followed by skin and subcutaneous tissue problems (13.9%). The patients' initial diagnoses were statistically associated with admission rate ($p = 0.024$). The admission group had a higher mean CCI than the discharge group (2.25 $\pm$ 2.14 vs. 0.68 $\pm$1.43, $p < 0.001$). We also found that revisiting patients with high CCIs had a higher admission rate (67.3% vs. 22.7%; $p < 0.001$) than low CCI patients. The patients with high CCIs had a more than fivefold increased odds ratio of admission after revisiting than those with low CCIs (OR 5.12; 95% CI 1.95-13.43).

The patients with high comorbidity had increased odds ratio of admission after adjustment for the potential confounders of age and initial diagnosis (OR 2.06; 95% CI 1.14-3.75). The initial diagnoses still had a statistically significant correlation with admission after adjustment (OR 1.11; 95% CI 1.04-1.18). However, age did not statistically increase the adjusted odds ratio of admission (OR 1.06; 95% CI 0.09-1.24).

The frequency and the index weight of different comorbid diseases in the admission group are shown in Table 3. The most frequent underlying conditions were diabetes-related (25.7%), followed by malignancy-related conditions (20.6%) and liver disease (13.7%).

Among the 60 admitted revisiting patients, high comorbidity patients had longer hospital stays (11.79 $\pm$ 8.92 days vs. 6.78 $\pm$ 5.17 days; $p < 0.05$) than low comorbidity patients (Table 4). We also found those admitted revisiting patients who had longer hospital stays had increased odds ratio of high CCI (OR 1.11; 95% CI 1.01-1.23). This result did not change after adjusting for other potential confounders (adjusted OR 1.11; 95% CI 1.00-1.23). Five patients (15.1%)

Table 2. Characteristics of Admission and Discharge Groups of Patients Revisiting within 72 Hours

Characteristics	Admission group n = 60 (%)	Discharge group n = 108 (%)	*p* value	Crude OR (95% CI)
Gender				
Female	34 (56.7)	57 (52.8)	0.747	1.00
Male	26 (43.3)	51 (47.2)		0.89 (0.43-1.88)
Age (years)				
18-30	4 (6.7)	30 (27.8)		1.00
31-45	9 (15)	30 (27.8)		1.84 (0.48-7.00)
46-65	24 (40)	31 (28.7)	0.000*	2.41 (0.68-8.95)
Over 66	23 (38.3)	17 (15.7)		4.40 (1.14-16.95)*
Mean ± S.D.	58.53 ± 15.27	44.87 ± 18.10		
Initial diagnosis				
Circulatory	6 (10.0)	6 (5.5)		1.00
Mental	0 (0)	1 (0.9)		N/A
Respiratory	5 (8.3)	10 (9.3)		0.50 (0.11-2.38)
Digestive	19 (31.7)	29 (26.9)		0.66 (0.18-2.34)
Genitourinary	5 (8.3)	8 (7.4)	0.024*	0.63 (0.13-3.07)
Skin and subcutaneous tissue	1 (1.7)	15 (13.9)		0.07 (0.01-0.68)
Musculoskeletal	2 (3.3)	4 (3.7)		0.50 (0.07-3.85)
Symptom-based	9 (15.0)	28 (25.9)		0.32 (0.08-1.25)
Malignancy-related	13 (21.7)	7 (6.5)		1.86 (0.43-7.98)
Charlson Comorbidity Index				
Low comorbidity	27 (45)	92 (85.2)		1.00
High comorbidity	33 (55)	16 (14.8)	0.000*	5.12 (1.95-13.43)*
Mean ± S.D.	2.25 ± 2.14	0.676 ± 1.43		

Abbreviations: OR: odds ratio; CI: confidence interval; S.D.: standard deviation; N/A: not applicable; *: $p < 0.05$

Table 3. Frequency of Charlson Comorbidity Index Categories of 60 Admitted Patients who Revisited within 72 Hours

Condition	Weight	Frequency, n = 73 (%)
Myocardial infarction	1	4 (5.5)
Congestive heart failure	1	4 (5.5)
Peripheral vascular disease	1	1 (1.4)
Cerebrovascular accident1	1	1 (1.4)
Dementia	1	0 (0)
Chronic pulmonary disease	1	5 (6.8)
Connective tissue disease	1	1 (1.4)
Gastrointestinal ulcer disease	1	8 (11)
Mild liver disease	1	4 (5.5)
Diabetes mellitus	1	17 (23.2)
Hemiplegia	2	0 (0)
Moderate to severe renal disease	2	5 (6.8)
Diabetes with end-organ damage	2	2 (2.7)
Any tumor	2	8 (11)
Leukemia	2	1 (1.4)
Lymphoma	2	0 (0)
Moderate or severe liver disease	3	6 (8.2)
Autoimmune deficiency syndrome	6	0 (0)
Metastatic solid tumor	6	6 (8.2)

with high comorbidity expired during admission, with admission stays of 3, 5, 11, 11 and 20 days, respectively. Their mean CCI was 4.33. One patient from the low comorbidity group died within 7 days of revisiting. However, the difference in in-hospital mortality rates between the high and low co-morbidity groups was not significant (15.2% vs. 3.7%; $p = 0.209$).

In Table 5, among the total of 168 enrolled patients, those with high CCIs were significantly older than the low CCI patients (60.41 ± 13.43 years vs. 43.36 ± 19.29 years; $p < 0.001$). We also found older patients (age > 46 years) had increased odds ratio of high CCI (OR 17.28; 95% CI 2.13-140.13).

DISCUSSION

Some studies on ED revisiting have aimed at explaining why patients returned and identifying medical errors.[1,2] Others have focused on risk factors for ED revisits, especially in the elderly.[5-7] The CCI

Table 4. Correlations between Charlson Comorbidity Index and Characteristics of 60 Admitted Patients who Revisited within 72 Hours

Characteristics	Low comorbidity patients n = 27 (%)	High comorbidity patients n = 33 (%)	*p* value	Crude OR (95% CI)	Adjusted OR (95% CI)†
Gender					
Female	15 (55.6)	19 (57.6)	0.875	0.69 (0.21-2.25)	0.81 (0.18-3.56)
Male	12 (44.4)	14 (42.4)		1.00	1.00
Age (years)					
18-30	4 (14.8)	0 (0)	0.095	N/A	N/A
31-45	5 (18.5)	4 (12.1)		1.61 (0.31-8.27)	1.59 (0.23-10.96)
46-65	10 (37.0)	14 (42.4)		0.80 (0.22-2.92)	0.94 (0.22-4.11)
Over 66	8 (29.7)	15 (45.5)		1.00	1.00
Mean ±S.D.	53.26 ±17.13	62.85 ±12.79			
Length of stay					
Mean ±S.D.	6.78 ±5.17	11.79 ±8.92	0.003*	1.11 (1.01-1.23)*	1.11 (1.00-1.23)*
In-hospital mortality					
Dead	1 (3.7)	5 (15.2)	0.209	0.29 (0.03-3.36)	0.33 (0.03-4.18)
Alive	26 (96.3)	28 (84.8)		1.00	1.00

Abbreviations: OR: odds ratio; CI: confidence interval; N/A: not applicable; S.D.: standard deviation; *: $p < 0.05$; †: adjusting for other variables in the Table

Table 5. Correlations between Charlson Comorbidity Index and Characteristics of 168 Revisiting Patients

Characteristics	Low comorbidity patients n = 119 (%)	High comorbidity patients n = 49 (%)	*p* value	Crude OR (95% CI)
Gender				
Female	65 (54.6)	26 (53.1)	0.866	1.00
Male	54 (45.4)	23 (46.9)		1.19 (0.54-2.63)
Age (years)				
18-30	33 (27.7)	1 (2.0)	0.000*	1.00
31-45	34 (28.6)	5 (10.2)		3.86 (0.41-36.35)
46-65	31 (26.1)	24 (49.0)		17.28 (2.13-140.13)*
Over 66	21 (17.6)	19 (38.8)		16.64 (1.98-139.57)*
Mean ±S.D.	43.36 ±19.29	60.41 ±13.43		

Abbreviations: OR: odds ratio; CI: confidence interval; S.D.: standard deviation; *: $p < 0.05$

has been used to account for the impact of comorbid conditions and to predict the outcomes of studies on conditions such as ischemia stroke, peritoneal dialysis, hemodialysis and trauma.[10-13] Our study showed that the CCI could be used successfully as a clinical tool to measure comorbidity of ED revisiting patients and predict possibility of admission.

A previous study found that the CCI correlates to 90 day revisits, hospitalization or death among older persons discharged from the ED.[14] In our study, the index might correlate with in-hospital mortality and length of hospital stay among the admitted patients who had revisited the ED within 72 hours. However, the higher in-hospital mortality rate of the high CCI patients did not significantly differ from the low CCI patients after admission. This may be due to the small population size of the admission group. As other factors may contribute to in-hospital mortality and length of hospital stay, further prospective studies are required.

One study on admissions of patients revisiting the ED within 72 hours identified patients older than 65 years, elderly patients with insurance and initial diagnosis as risk factors.[8] We also revealed that age correlated to the prognosis of ED revisiting patients. The age of the admission and high comorbidity groups were higher than the comparison population in our study. However, age of revisiting patients did

not increase the odds ratio of admission after adjustment for CCI and initial diagnosis. Further, the CCI of the revisiting patients was highly correlated to their age. We suggest that the effect of age on the admission rate of revisiting patients is through its impact on the CCI but further studies are required to prove this hypothesis.

In the previous study,[8] some initial diagnoses categories were identified as having a higher risk for ED revisiting, such as mental disorder, genitourinary system diagnoses and symptom-based diagnoses. In our study, the initial diagnoses correlated with the admission of revisiting patients after adjusting for the influence of age and CCI. However, some initial diagnoses categories were included in the CCI scoring classification and confounded each other. This did not increase the adjusted odds ratio of admission to a great extent.

Appropriateness of management is very important in the era when medical costs and medico-legal liability are both major concerns for physicians. Though objective criteria may provide important reference points for emergency physicians, critical clinical decision-making on individual patients in specific situations and conditions still depends on the judgment of physicians. A clinically applicable prognostic model is only possible after researching larger study populations for longer study periods. A few such models have been developed to address particular clinical questions, such as outcomes of ischemic stroke,[15] five-year survival after first-ever stroke,[16] model for functional recovery in stroke[17] and predictors of stroke outcome using objective measurement scales.[18] The methodology of the above research can be used to study predictive factors for ED patients. Hence, use of a validated index such as CCI may improve our clinical practice by properly assessing the comorbidity severity in the ED.

Though most unscheduled revisits were due to disease-related factors rather than medical errors, almost one-third of these cases are avoidable.[3,4] Some patients who are admitted upon return should have been admitted on their first visit. If they can be discovered, the revisit admission rate might be reduced. This group of patients probably has high CCIs. Targeting specific populations of ED users is a cost-effective strategy to reduce overcrowding in the ED. Elderly patients with high CCIs and poor physical conditions are a high-risk group that requires more attention.

Some limitations of the study have to be taken into consideration. First, our study period was short. Second, the revisit rate (2.9%) in our study was similar to previous studies, which was around 1.3%-3.4%.[3,19,20] The rate of admission after revisit in our study (0.98%) was higher than one study (0.58%).[8] In addition to disease severity, other factors may affect emergency physicians' decisions, including physician practice behavior, patient and family expectation, and social factors. Third, 30 days mortality could not be included for comparison with high and low CCI groups because it was not available in this retrospective review study.

In conclusion, high comorbidity (CCI ≥ 2) ED revisiting patients had a higher admission rate, poorer prognosis, longer hospital stays and high in-hospital mortality. The CCI provides a good measure of comorbid condition severity and correlates well with the admission possibility of ED revisiting patients. Further prospective studies are required to prove the efficacy of CCI to predict the prognosis of ED revisiting patients. More clinical management and discharge strategies should be focused on those patients revisiting within 72 hours who have more comorbid medical conditions.

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Charlson Comorbidity Index 在急診三日內回診的應用

王瀚儀 周 義 龔嘉德 鍾昆融 李文輝

背 景： 本研究的目的是使用 Charlson Comorbidity Index (CCI) 來評估急診 72 小時再回診病人的合併症嚴重程度，並預估回診病患住院的可能性。

方 法： 本項回溯性病歷觀察研究，收集某急診在西元 2004 年一月間 72 小時回診的成人非外傷病人。分別記錄他們的年齡、性別、初始的診斷、住院天數、出院狀態並計算他們的 Charlson Comorbidity Index 分數。並且把他們分成回診後住院與出院兩組，加以比較之間的差異。

結 果： 在 168 個個案中，有 60 位病人在回診後住院。其餘的 108 位病人在回診後出院。我們發現回診病人中有較高合併症嚴重度 (CCI ≥ 2) 的病人比起嚴重度較低的病人有比較高的住院比率 (67.3% vs. 22.7%; $p < 0.001$)。這些病人會有較高的風險會住院 (adjusted odd ratio [OR] 2.06; 95% confidence interval [CI] 1.14-3.75)，並且在住院之後會有較長的住院天數 (11.79 ± 8.92 days vs. 6.78 ± 5.17 days; $p < 0.05$) 與較高的在醫院死亡率 (15.2% vs. 3.7%; $p = 0.209$)。

結 論： Charlson Comorbidity Index 的高低跟急診回診病人之住院與否有很好的相關性。我們對於 72 小時內回診的急診病人，若有較高的合併症嚴重度應給予更多的臨床處置和不同的出院策略。

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關鍵詞：Charlson Comorbidity Index，急診，返診

長庚紀念醫院 高雄院區 急診醫學科；長庚大學 醫學院
受文日期：民國95年6月2日；接受刊載：民國96年2月8日
通訊作者：李文輝醫師，長庚紀念醫院 急診醫學科。高雄縣833鳥松鄉大埤路123號。Tel.: (07)7317123轉8415; Fax: (07)7317123轉8787; E-mail: Malee4950@cgmh.org.tw