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Article *in* Journal of clinical epidemiology · March 2010

Impact Factor: 3.42 · DOI: 10.1016/j.jclinepi.2009.11.013 · Source: PubMed

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Journal of Clinical Epidemiology 63 (2010) 1036−1044

Journal of Clinical Epidemiology

Geriatrics index of comorbidity was the most accurate predictor of death in geriatric hospital among six comorbidity scores

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Accepted 18 November 2009

Abstract

Objectives: To compare the abilities of six validated comorbidity indices (Charlson index, cumulative illness rating scale [CIRS], index of coexistent diseases, Kaplan scale, geriatrics index of comorbidity [GIC], and chronic disease score) to predict adverse hospitalization outcomes (death during hospitalization, length of stay, and institutionalization).

Study Design and Setting: Prospective cohort of 444 elderly inpatients (mean age 85.3) was randomly selected from Geneva geriatric hospital.

Results: In univariate analyses, GIC was the best predictor for all outcomes. The risk of death was 30 times higher and the risk of prolonged hospitalization and being institutionalized was eight to nine times higher in patients with scores of class 3 or 4. In adjusted logistic regression models, GIC remained the best predictor of death during hospitalization. Higher GIC scores accounted for 25% of the variance of this outcome, with mortality rates differing by a factor of four between the highest and the lowest scores. CIRS was a strong predictor of a prolonged hospital stay and institutionalization, accounting for 10% of the variance of these outcomes.

Conclusion: GIC was the most accurate predictor of death during hospitalization. CIRS could be used to select elderly patients at admission as an indicator of improvement at discharge.

Keywords: Comorbidity scores; Aged; Elderly; Death; Length of stay; Institutionalization

1. Introduction

Elderly patients often suffer from multiple chronic conditions that individually and jointly affect their quality of life, use of health services, morbidity, and mortality [1]. Several indices have been proposed to quantify comorbidity in adults. However, only some of them are valid and reliable for use as a measure of comorbidity in applied clinical research [2] or in elderly patients [3,4]: (1) The Charlson comorbidity index (CCI) is the most extensively studied comorbidity index (CI) for predicting mortality. It is a weighted index that takes into account the number and severity of comorbid conditions [5]. This index was created to enhance the prediction of 1-year mortality in a cohort of medical young patients, but it has been used to predict other health outcomes, such as functional status. It gives a highest weight for conditions that are not frequent (i.e., AIDS) in the elderly; and for other conditions, so frequent in elderly patients (i.e., dementia) the weight is lower, (2) the cumulative illness rating scale (CIRS) addresses all relevant physiological systems rather than being based on specific diagnoses and consists of two parts: the CI and the severity index [6]. The advantage of this scale built for geriatrics patients is that it assesses the severity of diseases according to their impact of disability, (3) The index of coexisting disease (ICED) was developed to predict in-hospital postoperative complications and 1-year health-related quality of life of patients who underwent total hip replacement surgery. This index has a 2-dimensional structure, measuring disease severity and disability, which can be useful when considering mortality and disability as the outcomes of interest [7]. A major limitation of the ICED is that it requires medical records and highly trained reviewers who must follow complex decision rules in creating the index, (4) The Kaplan index was developed specifically for use in diabetes research [8], (5) the geriatrics index of comorbidity (GIC) takes into account the number and severity of diseases,

No author received any consultancy fees or has any company holdings or patents. There are no conflicts of interest.

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doi: 10.1016/j.jclinepi.2009.11.013

but although it was built for geriatric patients, it has the peculiarity of not including disability [9], and (6) the chronic disease score (CDS) is an alternative CI based on the drugs taken by the patient rather than clinical diagnoses [10].

These tools were initially validated in institutionalized elderly patients in a retrospective manner. A previous study examined the prognostic value of the CCI in predicting a 3-year mortality and functional decline in patients receiving long-term care from 88 residential care facilities in Quebec, Canada (291 dependent elderly adults with a mean age of 83.3 years). The CCI performed well in predicting both outcomes [11]. The CIRS is significantly associated with mortality, acute hospitalization, medication usage, laboratory test results, and functional disability among frail elderly institutionalized patients [6]. Recently, Di Bari et al. [12] showed that these measures of comorbidity (CCI, ICED, GIC, and CDS) predicted death and disability in basic activities of daily life in 688 Italian community dwellers with a mean age of 74 years. However, the value, relevance, and pertinence of these CIs as predictors of hospitalization adverse outcomes in the very elderly remain unknown.

In this prospective study, we compared the performance of these six validated and widely used CIs in predicting adverse hospitalization outcomes in the elderly, including death during the hospitalization period, a prolonged hospital stay, and institutionalization. The study population was derived from a study cohort of very elderly, acutely ill geriatric inpatients.

2. Methods

2.1. Patients and data collection

We carried out a prospective study in a 300-bed geriatric hospital (HOGER) of the University Hospitals of Geneva, Switzerland, for acute illness. Patients and data collection have been described elsewhere [13]. Briefly, patients were recruited by clinically trained staff. All patients older than 75 years and consecutively admitted on selected days between January 2004 and December 2005 were included. We selected a random sample of patients for each day, using a computer-generated randomization table. The local ethics committee approved the protocol, and the patients or their families or legal representatives gave signed written informed consent. Demographic data for the patients studied did not significantly differ from data for all patients admitted to the HOGER during 2004−2005. Our sample was therefore representative of all patients admitted to this hospital, demonstrating the reliability of the randomization procedure used in this study.

Medical history was recorded on a standardized form and the same geriatrician carried out physical examinations on all patients. Annual follow-up over a 4-year period, with the same assessment carried out each year, was planned in the study protocol.

2.2. Sociodemographic data

The data recorded included age, sex, native language, marital status, living arrangement, and educational level.

2.3. Cognitive diagnosis

The same neuropsychologist assessed all subjects for clinical dementia, at least 1 week after admission, to avoid the effects of concomitant delirium. The mini-mental state examination scores (0−30) [14] and the short cognitive evaluation battery [15,16] were used. Based on screening results, the same neuropsychologist then carried out a comprehensive standardized neuropsychological assessment to determine the etiology and severity of clinical dementia, as previously described [13].

2.4. Assessment of comorbidity

The same geriatrician calculated all six scores for each patient by extensive review of the patient's medical records and administrative data for diagnoses established at or before enrollment in this study.

1. Charlson comorbidity index [5]

   The CCI is a list of 19 conditions; each is assigned a weighting (1−6). Weightings reflect the ability of each condition to predict 1-year mortality, as originally reported for cancer patients. They are fixed for each diagnosis and range from 1 (for conditions, such as myocardial infarction or mild liver disease, with a relative risk $\geq$1.2 and $<$1.5) to 6 (assigned to metastatic cancer, with a relative risk $\geq$6). The CCI is the sum of the weightings for all conditions observed in a patient—higher scores indicated greater comorbidity.

2. Cumulative illness rating scale [6]

   The CIRS identifies 14 items, corresponding to different systems. Each system is scored as follows: 1 (none)—no impairment to that organ or system; 2 (mild)—impairment does not interfere with normal activity, treatment may or may not be required, prognosis is excellent; 3 (moderate)—impairment interferes with normal activity, treatment is needed, prognosis is good; 4 (severe)—impairment is disabling, treatment is urgently needed, prognosis is guarded; 5 (extremely severe)—impairment is life threatening, treatment is urgent or of no avail, poor prognosis. The illness severity index (summary score based on the average of all CIRS items, excluding psychiatric or behavioral factors) and the CI (summary score based on a count of organ system with moderate or greater impairment, excluding psychiatric or behavioral factors) can then be calculated using these scores.

3. Index of coexistent diseases [7]

   The ICED is based on the presence and severity of 19 medical conditions and 11 physical impairments, using two scales: the index of disease severity (IDS) and the index of physical impairment (IPI). The final ICED score is determined by an algorithm combining the peak scores for the IDS and IPI. The ICED score ranges from zero to three (four classes), reflecting increasing severity.

4. Kaplan scale [8]

   This index uses two forms of classification: focusing on the type of comorbidity and the pathophysiologic severity of the comorbid conditions present, respectively. The type of comorbidity can be classified as vascular (hypertension, cardiac disorders, peripheral vascular disease, retinopathy, and cerebrovascular disease) or nonvascular (lung, liver, bone, and nondiabetic renal diseases). Pathophysiologic severity is rated on a 4-point scale, ranging from zero (comorbidity is absent or easy to control) to three (recent full decompensation of comorbid disease). The rating of the most severe condition determines the overall comorbidity score. Scores for vascular and nonvascular comorbidity can be calculated, based on the most severe condition in each subscale.

5. Geriatric index of comorbidity [9]

   In computing the GIC, each of the 15 more prevalent clinical conditions (ischemic or organic heart diseases, primary arrhythmias, heart diseases with a nonischemic or nonorganic origin, hypertension, stroke, peripheral vascular diseases, diabetes mellitus, anemia, gastrointestinal diseases, hepatobiliary diseases, renal diseases, respiratory diseases, parkinsonism and nonvascular neurologic diseases, musculoskeletal disorders, and malignancies) is graded on a 0–4 disease severity scale on the basis of the following general framework: 0 = absence of disease, 1 = asymptomatic disease, 2 = symptomatic disease requiring medication but under satisfactory control, 3 = symptomatic disease uncontrolled by therapy, and 4 = life-threatening or the most severe form of the disease. The GIC classifies patients into four classes of increasing somatic comorbidity. Class 1 includes patients who have one or more conditions with a disease severity grade equal to or lower than 1. Class 2 includes patients who have one or more conditions with a disease severity grade of 2. Class 3 includes patients who have one condition with a disease severity of 3, other conditions having a disease severity equal to or lower than 2. Class 4 includes patients who have two or more conditions with a disease severity of 3 or one or more conditions with disease severity of 4.

6. Chronic disease score [10]

   This is a measure of comorbidity obtained from a weighted sum of scores based on the use of 30 different classes of medication. An integer weight between one and five is given to each of the selected classes of medication; the overall score is then the sum of the weightings.

2.5. Adverse outcomes of hospitalization

The adverse outcomes considered include hospital stays greater than the median value, death during the hospitalization period, and changes in living arrangements at discharge (institutionalization).

2.6. Statistical methods

We checked for the normal distribution of data for continuous scores (CCI, CIRS, Kaplan scale, and CDS) using skewness and kurtosis tests and carried out standard transformations to normalize non-Gaussian variables. As it was not possible to normalize these scores, they were categorized into quartiles to facilitate comparison with the four classes of the other two indices, ICED and GIC. Colinearity among the six indices was checked using Spearman rank correlation coefficient. Multiple logistic regression analysis was then carried out using age, sex, and the six comorbidity scores as independent variables and each outcome as dependent variable to identify the best predicting score for each outcome, whereas adjusting for all the others. Outcomes were considered as dichotomous data (death during hospitalization, a prolonged hospital stay [longer than the median duration], admission to long-term care). Odds ratios and 95% confidence intervals were calculated. Statistical analyses were performed with Stata software version 10.1 (StataCorp LP, College Station, TX, USA).

3. Results

We included 444 patients in this study (mean age 85.3 ± 6.7, 74% women). Table 1 summarizes frequency distribution of patients according to each comorbidity score.

As there were no patients in the ICED classes 1 and 2, we considered only classes 3 and 4, providing binary data for the analyses. Likewise, only 2% of the patients were classified as class 1 by the GIC, allowing us to combine classes 1 and 2 for the analysis.

For the other four indices, the distribution was almost equal among the four quartile ranges, with approximately 25% of the patients per range.

Table 2 shows the patient's destination after hospitalization, comparing living arrangement before and after.

3.1. Univariate and multiple logistic regression analysis

Spearman rho values among the six indices ranged between 0.038 and 0.548, which does not meet the criteria for

Table 1
Quartile range and frequency of six comorbidity scores

	CCI		CIRS		ICED[a]	Kaplan		GIC[a]	CDS	
Level/classes[a]	Quartile range score	*N* (%)	Quartile range score	*N* (%)	*N* (%)	Quartile range score	*N* (%)	*N* (%)	Quartile range score	*N* (%)
1	0−3	165 (37)	0−11	121 (27)	0	0−2	128 (29)	9 (2)	0−3	122 (28)
2	4	91 (20)	12−14	107 (24)	0	3−4	156 (35)	34 (8)	4−6	117 (26)
3	5−6	91 (20)	15−18	119 (27)	93 (21)	5	55 (12)	310 (70)	7−8	109 (24)
4	7−14	97 (23)	19−30	97 (22)	351 (79)	6−16	105 (24)	91 (20)	9−15	96 (22)

Data are expressed as number of cases (%).

Abbreviations: CCI, Charlson comorbid index; CIRS, cumulative illness rating scale; ICED, index of coexistent diseases; Kaplan, Kaplan scale; GIC, geriatrics index of comorbidity; CDS, chronic disease score.

[a] Quartile ranges do not apply to ICED and GIC, because continuous scores were not calculated using these tools and patients were assigned directly to four classes.

colinearity usually set at >0.900. We carried out univariate logistic regression analyses including age, sex, and the six CIs tested predicting the three adverse hospitalization outcomes (Table 3). We then tested full multiple logistic regression models containing all the variables. No new differences were observed; thus, results are presented only with variables that were positive in the univariate models.

3.1.1. Length of stay (median = 32 days)

In univariate analysis, age, quartiles or class 3 or 4 scores were found to be independent predictors of prolonged hospitalization. GIC class 4 scores were the strongest predictors of a prolonged stay in hospital, with a difference of a factor of nine in adverse outcome rate between patients with the highest and lowest scores.

This association was not observed when all variables were introduced into the analysis, with only the third and fourth quartiles of CIRS scores remaining statistically significant and accounting for 10% of the variability of this outcome. Higher classes of the ICED also remained weakly significant, with $P = 0.045$.

3.1.2. Death during hospitalization

Of the 444 patients, 27 died during the hospitalization period (6%). In univariate analysis, mortality was significantly associated with age (not with sex) and with the highest score of the CCI, CIRS, ICED, Kaplan scale, and GIC but not with the CDS. GIC class 4 scores were the strongest predictors of death during hospitalization, with a difference of a factor of 37 in adverse outcome rates between patients with the highest and lowest scores.

When all variables were included in the model, only the GIC classes 3 and 4 remained statistically significant. Higher GIC comorbidity scores accounted for 24% of the variance of this outcome. Higher classes of the ICED score also remained weakly significant, with $P = 0.045$.

3.1.3. Institutionalization

Table 2 summarizes the destinations of patients after hospitalization. Sixty-one (14.3%) patients were institutionalized and 10% of the initial cohort was transferred to another hospital (surgery, intensive care).

Univariate analysis revealed that institutionalization was significantly associated with the highest score of the CIRS, ICED, Kaplan scale, and the GIC but not with the CCI or CDS. GIC class 4 and CIRS fourth quartile scores were the strongest predictors of this outcome, with the rate of institutionalization differing by factors of nine and five, respectively, between patients with the highest and lowest scores.

When all variables were included in the model, only the CIRS classes 3 and 4 remained statistically significant. Higher CIRS comorbidity scores accounted for 10% of the variance of this outcome.

3.1.4. Summary of results

Of the six indices, the GIC explained the largest percentage of variation in the frequency of these three outcomes in

Table 2
Destination after hospitalization ($n = 444$)

Living arrangements		After hospitalization						
Before hospitalization	Total *N* (%)	Alone	Partner	Family	Protected residence	Nursing home	Died in hospital	Transfer
Alone	258 (58)	179	0	0	0	36	16	27
Partner	105 (27)	0	70	0	0	15	7	13
Family	36 (8)	0	0	27	0	3	1	5
Protected residence	27 (6)	0	0	0	16	7	3	1
Nursing home	18 (4)	0	0	0	0	17	0	1
Total *N* (%)		179 (40)	70 (16)	27 (6)	16 (4)	78 (18)	27 (6)	47 (10)

Data are expressed as number of cases (%).

Table 3
Univariate and multivariate logistic regression including all variables for predictors of the three adverse hospitalization outcomes (length of stay greater than the median, death during hospitalization, institutionalization) ($n = 444$)

		Univariate logistic regression		Multiple logistic regression	
Outcomes	Independent variables	Crude OR	95% CI	Adjusted OR	95% CI
Length of stay					
	Age	1.03	1.00−1.06*	1.02	0.99−1.05
	Male vs. female	0.91	0.60−1.39		
	CCI				
	Quartile				
	1	1.00	—		
	2	1.27	0.76−2.12		
	3	1.77	1.07−2.94*	1.24	0.66−2.32
	4	1.89	1.12−3.17*	1.45	0.79−2.65
	CIRS				
	Quartile				
	1	1.00	—		
	2	1.82	1.07−3.09*	1.36	0.72−2.54
	3	3.51	2.03−6.07***	3.00	1.64−5.46***
	4	5.07	2.84−9.04***	4.08	1.91−8.7***
	ICED				
	Class				
	1 + 2 + 3	1.00	—		
	4	2.00	1.24−3.2*	1.73	1.01−2.96*
	Kaplan				
	Quartile				
	1	1.00	—		
	2	1.38	0.73−2.6	0.59	0.27−1.30
	3	2.10	1.30−3.39**	1.10	0.53−2.27
	4	2.40	1.42−4.08***	1.32	0.75−2.29
	GIC				
	Class				
	1 + 2	1.00	—		
	3	8.22	3.46−19.5***	0.88	0.33−2.33
	4	9.03	4.08−20.0***	1.56	0.69−3.52
	CDS				
	Quartile				
	1	1.00	—		
	2	1.88	1.11−3.17*	1.18	0.65−2.14
	3	2.03	1.18−3.50**	1.57	0.83−2.94
	4	2.06	1.23−3.46**	1.61	0.92−2.85
Death in hospital					
	Age	1.07	1.00−1.15*	1.06	0.98−1.15
	Male vs. female	0.99	0.38−2.6		
	CCI				
	Quartile				
	1	1.00	—		
	2	1.68	0.88−3.20		
	3	1.74	0.92−3.27		
	4	2.49	1.34−4.60**	1.15	0.96−1.37
	CIRS				
	Quartile				
	1	1.00	—		
	2	1.72	1.07−3.09		
	3	4.29	2.03−6.07		
	4	6.84	2.84−9.04*	1.21	0.20−7.14
	ICED				
	Class				
	1 + 2 + 3	1.00	—		
	4	[a]	*	1.36	1.01−1.83*

(*Continued*)

Table 3
Continued

Outcomes	Independent variables	Univariate logistic regression		Multiple logistic regression	
		Crude OR	95% CI	Adjusted OR	95% CI
	Kaplan				
	Quartile				
	1	1.00	—		
	2	1.23	0.20−7.50		
	3	4.94	0.88−27.82		
	4	9.70	2.14−43.69**	1.71	0.28−10.50
	GIC				
	Class				
	1 + 2	1.00	—		
	3	34.30	13.75−87.82***	3.68	3.01−6.26***
	4	37.14	14.75−93.53***	4.34	3.92−9.52***
	CDS				
	Quartile				
	1	1.00	—		
	2	0.62	0.14−2.64		
	3	1.60	0.49−5.21		
	4	2.13	0.67−6.70		
Institutionalization					
	Age	1.05	1.00−1.10*	1.03	0.98−1.08
	Male vs. female	0.95	0.50−1.80		
	CCI				
	Quartile				
	1	1.00	—		
	2	1.42	0.66−3.07		
	3	1.50	0.70−3.20		
	4	1.69	0.80−3.57		
	CIRS				
	Quartile				
	1	1.00	—		
	2	1.98	0.77−5.09		
	3	2.98	1.23−7.21*	2.73	1.10−6.77*
	4	5.53	2.31−13.21***	5.56	2.18−14.22***
	ICED				
	Class				
	1 + 2 + 3	1.00	—	—	—
	4	2.31	1.05−5.08*	1.75	0.75−4.03
	Kaplan				
	Quartile				
	1	1.00	—		
	2	1.65	0.69−3.89		
	3	2.22	0.88−5.55		
	4	2.27	1.09−4.72*	1.65	0.91−3.00
	GIC				
	Class				
	1 + 2	1.00	—		
	3	3.25	1.24−11.20***	1.50	0.39−5.79
	4	4.62	3.46−13.20***	1.53	0.32−7.25
	CDS				
	Quartile				
	1	1.00	—		
	2	0.57	0.24−1.43		
	3	0.94	0.44−2.04		
	4	1.40	0.70−2.844		

Abbreviations: OR, odds ratio; CI, confidence interval; CCI, Charlson comorbid index; CIRS, cumulative illness rating scale; ICED, index of coexistent diseases; Kaplan, Kaplan scale; GIC, geriatrics index of comorbidity; CDS, chronic disease score.

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

[a] ICED class 4 strongly predicts the outcome.

univariate analyses. When all scores were compared in a logistic regression after controlling for age and sex, the GIC remained a strong predictor for death during hospitalization.

However, the CIRS performed better than the other indices in predicting a prolonged hospital stay and institutionalization. The CDS performed the most poorly for predicting death during hospitalization and institutionalization. The risk of being hospitalized for longer than the median ranged from 1.88 for the lower scores to 2.06 for the higher scores, showing poor discrimination between these groups of patients. CCI scores were not predictive of institutionalization at all and were less predictive of prolonged hospitalization or death during hospitalization than the ICED or Kaplan scale.

4. Discussion

One of the main strengths of this study was the comprehensive and detailed assessment of the presence and extent of comorbidities: the same medical doctor scored the six CIs for all patients to ensure a high accuracy of scoring. The prospective collection of comorbidity data allowed better control over the quality of the data needed to quantify comorbidity. We carried out, for the first time, a prospective study comparing the use of six CIs—the most widely used and validated in elderly subjects—for the prediction of three adverse outcomes of hospitalization in elderly patients with acute disease. Previous studies, as described earlier, have used only one comorbidity score and have mostly been retrospective.

In our prospective study, introducing all parameters into the model, having checked for the absence of colinearity and adjusting for age and sex, the GIC provided a better measure of comorbidity than the other indices tested, when death during hospitalization was the outcome of interest. The CIRS could be used as a method for selecting elderly patients at admission and as a prognostic predictor for improvement at discharge. The results obtained for the CIRS were similar to previous findings in a retrospective analysis of patients aged 90−99 years, admitted over a 6-month period to a district hospital in Australia. One hundred three patients were included in the study with an average age of 92 years and a male-to-female ratio of 1:3. Fifty-five percent of hospitalized patients came from nursing care facilities. Characteristics of patients from nursing homes were compared with those of patients from the community. The physical burden of illness was measured by the CIRS. There was a significant ($P < 0.05$) correlation between high CIRS scores and duration of the hospital stay. The death rate for this group of patients was higher (13%) than the proportion of patients with a prolonged hospitalization period (10.2%). There were significant differences in the CIRS scores between patients who died and those who survived; the CIRS is thus potentially a useful tool in predicting this outcome [17]. In our univariate analysis, high CIRS scores were associated with death during hospitalization, with death rate differing by a factor of six between patients with the highest and lowest scores. These results confirmed those of Salvi et al. [18] that previously demonstrated the CIRS's ability to predict 18-month mortality and rehospitalization in a cohort of 387 patients aged 65 and older from an acute internal medicine ward. One advantage of the CIRS is its suitability for use in common clinical practice: it is based on measures of clinically relevant physiological systems and uses a clear and clinically sound ranking of severity. Given its validity and reliability, the CIRS seems to provide a very useful measure of comorbidity for clinical research. This index appears to be sufficiently reliable because it allows all the comorbid diseases from clinical examinations and medical files to be taken into account in a comprehensive manner [19]. The CIRS, however, has some limitations and improvements are needed, such as the inclusion of psychiatric disturbances, which are highly prevalent in the elderly. Such limitations may explain why, when all variables were included in the model, only the GIC class 3 and 4 scores remained statistically significant for the prediction of death during hospitalization.

Similarly, previous studies confirmed the impact of the GIC index on the prediction of 6-month survival in a population of 1,402 hospitalized elderly patients (age 80.1 ± 7.1 years; 68% female) with chronic disability consecutively admitted to an acute care unit in Italy. As observed in our study, patients with GIC class 1 and 2 scores were scarce in this acute geriatric ward. In a Cox regression analysis, adjusting for factors associated with mortality in univariate models (low levels of serum albumin and cholesterol, anemia, dementia, chronic obstructive pulmonary disease, coronary heart disease, renal diseases, gastrointestinal diseases, and advanced cancer) and taking class 2 as a reference, patients with GIC scores in class 4 had a risk of death three times higher than patients with the lowest scores [9].

The CDS was the poorest predictor for all the adverse outcomes considered. This is consistent with other previous studies. The low predictive value of this medication-based score for short-term outcomes may be because of the use of preventive treatments or treatment for benign conditions in healthier patients. For example, elderly women who are generally healthy and aware of health risks are likely to take lipid-lowering drugs and hormone replacement therapy. Such patients are likely to fare better than patients whose primary diagnosis has a poor short-term prognosis that may deter treatment of secondary conditions. This is consistent with earlier findings that sicker patients are less likely to be treated for comorbid conditions [20], particularly if these conditions are not immediately life threatening; additionally, medication for treating these conditions has preventive effects, for example, oral antidiabetic agents [21] or lipid-lowering drugs [22]. Users are thus often healthier than would be suggested by their medication-based scores. Although these findings are yet to be confirmed in other populations, they suggest that medication-based scores should be

used only in situations when the available data on the medication taken by the patients are of much better quality than the diagnostic data, or are the only source of information.

The CCI was not predictive of institutionalization at all and performed more poorly than the ICED or Kaplan scale for predicting prolonged hospitalization and death during hospitalization. The CCI is the most extensively studied CI for predicting mortality [2]. It was designed and scaled to predict mortality rather than functionally relevant comorbidity. This index does not take into account the severity of certain major diseases but only the presence of the disease. For example, in the case of congestive heart failure, patients with either a mild or a severe form of the disease will be assigned a score of 1. This index may therefore fail to identify important diseases, or their severity, in the elderly, which may otherwise act as predictors of adverse outcomes. The CCI has previously been found to be limited in determining the full range of diseases in elderly patients [19]. For this reason, some studies tried to outperform the CCI comparing the predictive capacity on mortality, readmission, and length of stay of the original CCI with a new CI regarding a larger range of diseases. Their results favor the utilization of newly developed indices [23,24]. On the contrary, Buntinx et al. [25], in a large cohort of 2,624 institutionalized elderly people, showed that the CCI is a predictor of short-term mortality and, to a lesser extent, also of hospitalization. In addition, the CCI has been shown to predict costs of chronic disease in primary care patients and in consequence being useful to predict resource utilization [26].

The GIC classifies patients based on increasing somatic comorbidity and takes into account disease severity. This probably explains why, when including all variables in the model, this index remained statistically significant and the best predictor for death during hospitalization in these elderly patients with acute disease. In the logistic regression model, the ICED also remained statistically, but weakly, significant. A distinct advantage of the ICED is that this index includes information on physical impairment in the assessment of comorbidity. Physical impairment is considered to be an additional dimension of comorbidity [27], reflecting symptomatic, uncontrolled, or advanced stages of disease. The ICED is the only one of these measures studied that has a 2-dimensional structure, measuring both the severity and extent of the disability associated with pathophysiologic disease. This could be particularly useful in studies assessing mortality and disability as outcomes of interest [2].

The Kaplan index performed well in our univariate analyses but lost all significance when all variables were controlled for. This index was specifically developed for use in diabetes research and contains clinically relevant information. It distinguishes between vascular and nonvascular comorbidity and uses severity rankings based on parameters derived from common clinical practice. The validity of this test makes the Kaplan scale a useful CI for clinical diabetes research [2] but probably less useful for assessing comorbidity in the elderly.

Currently, there is no accepted standardized method for measuring and quantifying the prognostic value of comorbid conditions in hospitalized elderly patients with acute disease. Our results showed that it is unlikely that any one particular index can be used to predict a variety of relevant outcomes. According to our results, the choice of measures will depend on the outcomes of interest as previously stated by Byles et al. [28]. We can recommend more usefully the GIC in predicting vital outcomes because of its link to physiological aspects of diseases, whereas the CIRS captures more comorbidity information related to the care because of its link to functional aspects of diseases. These findings have widespread implications for improved planning of the hospitalization period through the discharge of very ill elderly patients with acute disease.

The ways that health researchers have measured comorbidity has advanced our understanding in aging population but an important issue in geriatrics remains the need for new and better measures of the health status of elderly individuals that summarize the complex disorders that burdened them. Studies contrasting multimorbidity, which is defined—following van den Akker et al. study [29,30]—as the co-occurrence of two or more diseases in one person, without defining an index disease and comorbidity, corresponding to additional diseases to one index disease are needed. It would be essential to take into account not only the number of comorbid conditions and an index weighted by the severity of the comorbid conditions but also the associations among diseases.

Acknowledgments

The authors thank the teams of Mrs. O. Baumer, L. Humblot, and M. Cos for their technical assistance. This work was supported by grant 3200B0-102069 from the Swiss National Science Foundation.

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