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Comorbidity Assessments Based on Patient Report

Results From the Veterans Health Study

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Abstract: The objective of the study was to develop a self-reported measure of patients' comorbid illnesses that could be readily administered in ambulatory care settings and that would improve assessment of their health-related quality of life and utilization of health services. Data were analyzed from the Veterans Health Study, an observational study of health outcomes in patients receiving Veterans Administration (VA) ambulatory care. Patients who received ambulatory care services in 4 VA outpatient clinics in the greater Boston area between August 1993 and March 1996 were eligible for inclusion. Among the 4137 patients recruited, 2425 participated in the Veterans Health Study, representing a response rate of 59%. Participants were mailed a health-related quality of life questionnaire, the Medical Outcomes Study Short Form Health Survey (SF-36). They were also scheduled for an in-person interview at which time they completed a medical history questionnaire. We developed a comorbidity index (CI) that included 30 self-reported medical conditions (physical CI) and 6 self-reported mental conditions (mental CI). The physical CI and the mental CI were significantly associated with all SF-36 scales and explained 24% and 36%, respectively, of the variance in the physical component summary and the mental component summary of the SF-36. Both indexes were also significant predictors of future outpatient visits and mortality. The CI is an independent predictor of health status, outpatient visits, and mortality. Its use appears to be a practical approach to case-mix adjustment to account for differences in comorbid illnesses in observational studies of the quality of healthcare. It can be administered to large patient populations at relatively low cost. This method may be particularly valuable for clinicians and researchers interested in population-based studies, case-mix adjustment, and clinical trials. **Key words:** *case-mix*, *comorbidity*, *health-related quality of life*, *utilization of health services*

COMORBIDITY ASSESSMENT has become increasingly important in an era where evaluation of effectiveness, quality, and cost control have become central issues

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in medicine (Greenfield & Nelson, 1992). *Comorbidity* is a term used primarily to describe patient illnesses that may affect clinical outcomes (Iezzoni, 1997). Without adequate measures being in place to adjust for intervening comorbidity differences, valid comparisons of cost and benefits of healthcare cannot be made (Cleary et al., 1991; Greenfield et al., 1993; Salem-Schatz et al., 1994).

Many of the original methods used for measuring comorbidity depend on medical record review (Charlson et al., 1987). However, medical record audit requires skilled personnel and can be costly and difficult. In addition, the accuracy of medical chart–based comorbidity assessment relies on the quality of documentation in the medical record (Skinner et al., in press). These drawbacks have promoted a search for other methods.

Researchers have evaluated the use of insurance claims data, automated outpatient pharmacy data, and ICD-9-CM diagnoses (Deyo et al., 1992; Johnson et al., 1994; Roos et al., 1989; Von Korff et al., 1992). However, these approaches have their own problems. The use of insurance claims data may result in serious biases because these data are very closely related to utilization (Wennberg, 1987). Automated outpatient pharmacy data may be affected by utilization bias, dispensing patterns, and patient attitudes and preferences. Finally, the precision of an index based on ICD-9-CM diagnoses relies on the completeness and accuracy of diagnostic coding, which may vary by institution and service and whether inpatient or outpatient data are used.

Other investigators have focused on an alternative methodology, ie, one that is based on patient self-report. A variety of studies have shown that information provided by patients can be reliable, valid, and useful for many evaluative purposes (Bergmann et al., 1998; Katz et al., 1996; Linet et al., 1989). As a result, this approach is increasingly being recognized as a powerful way to address health issues that are particularly relevant to ambulatory care. It can be applied at a relatively low cost to a wide range of patient populations having a variety of chronic diseases, varying socioeconomic status, and different sources of care.

Three types of measures have been developed to assess comorbidity based on patient report. The first relies on self-reported diagnoses of chronic medical conditions (Fowles et al., 1996). Fowles and collaborators (1996) have demonstrated that this type of comorbidity measure can provide important information for calculating risk-adjusted capitation rates. It has been shown to be easy to administer in a large observational study. Greenfield and collaborators (1995) developed a second patient-based comorbidity measure that includes 15 symptom-based disease severity scales. These scales are weighted according to the expected impact of each disease category on functional status and are aggregated to produce a summary score of total disease burden. This measure, however, was created for use in a selected patient population, ie, patients with type II diabetes.

Fincke and collaborators (1995) developed the third self-reported measure of comorbidity, the Disease Burden Index (DBI), using pilot data from the Veterans Health Study (VHS) (Kazis et al., 2004). The DBI is a 40-item measure that includes symptoms and medical and mental conditions. These items were selected from the medical history questionnaire (MHQ), an inventory of diagnoses and symptoms developed in the Medical Outcomes Study (MOS) (Kravitz et al., 1992). This instrument was modified, validated, and used as a covariate in adjusted-risk models in the VHS (Kazis et al., 1998). However, this measure does not separate symptoms and medical conditions from psychiatric conditions.

We hypothesized that these patient-based comorbidity assessments might be improved in 2 ways. First, comorbidity assessments might benefit from a separation of conditions into medical and mental conditions since each of these may make different contributions in explaining variations in health outcomes and utilization of resources. Second, patient report of symptoms in lieu of established diagnoses might result in a more complete assessment since patients may report symptoms and not be aware of their diagnosis.

Thus, this article had 3 specific aims: (1) to create a patient-based comorbidity index (CI) that has 2 components, a physical CI (consisting of medical conditions) and a mental CI (consisting of psychiatric conditions); (2) to evaluate the discriminant validity of the CI index by examining its associations with health-related quality of life (HRQoL) and to evaluate its predictive validity by forecasting utilization of resources and survival; and (3) to substitute symptoms for some of the corresponding conditions in the physical CI, to form a condition/symptom CI, and to examine the relationships of this modified index to HRQoL, utilization of resources, and survival.

METHODS

Study sample

This study used data from the VHS, an observational study of health outcomes in patients receiving VA ambulatory care. The details of the VHS study design and sampling procedures have been described elsewhere (Fincke et al., 1995). Briefly, patients who received ambulatory care services in 4 VA outpatient clinics in the greater Boston area between August 1993 and March 1996 were eligible for inclusion. Of the 4137 patients recruited, 2425 participated in the VHS, representing a response rate of 59%. Women were not included in the VHS since their representation in the outpatient population of these 4 VA medical clinics was very low.

Measures

Participants were mailed an HRQoL questionnaire, the MOS Short Form Health Survey (SF-36) (Ware et al., 1993). They were also scheduled for an in-person interview at which time they completed an MHQ administered by a technician.

The SF-36* measures 8 different domains of HRQoL: physical functioning (PF), role limitations due to physical health (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), and mental health (MH). The SF-36 has been shown to be a reliable and valid instrument in ambulatory populations (McHorney et al., 1993; Ware et al., 1993, 1995). The SF-36 scales are scored from 0 (worst health) to 100 (best health). The 8 SF-36 scales can also be combined into 2 summary scales, the physical component summary (PCS) and the mental component summary (MCS). The 2 summaries are scored using a linear *t*-score transformation that is normed to a general US population, with a mean of 50 and a standard deviation of 10.

The MHQ is an inventory of diagnoses and symptoms developed in the MOS (Kravitz et al., 1992). This clinical assessment aims to obtain the level and kind of detailed data that can be derived directly from the patient on a broad inventory of medical problems. On the basis of the recommendations from a panel of general practitioners, we modified the original MHQ by editing and selecting items to obtain a more detailed and inclusive list of medical and psychiatric conditions. The questionnaire ascertained the presence or absence of 32 medical conditions, whether the patient had ever been treated for any of 7 mental problems, and the presence or absence of 31 symptoms.

We also collected the disability rating from the administrative database in the Veterans Health Administration (VHA) since the percentage of disability determines the priority for care and the amount of monetary compensation that veterans receive each month. The disability level is rated from 0% to 100%. Medical personnel evaluate the disabling condition and then rating specialists from the Veterans Benefits Administration determine the percentage of service-connected disability from standardized tables. Ratings of 0% are assigned when the service-connected condition is not considered to be disabling.

Development of CI

As summarized in Figure 1, the development of the CI started by identifying all conditions and symptoms questions included in the

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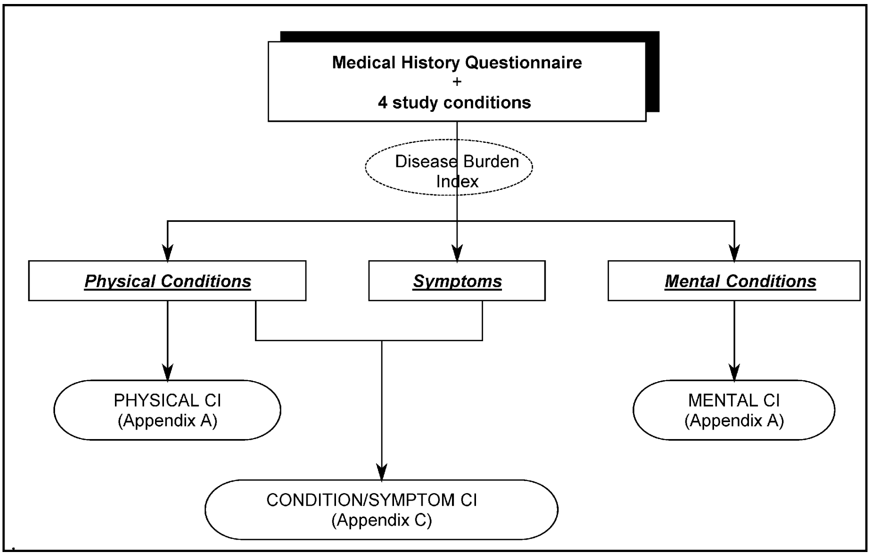

Figure 1. The development of cormobidity index.

MHQ. Then, we separated conditions from symptoms, yielding 2 lists. The list of conditions was further divided into medical conditions (32 self-reported physical conditions) and psychiatric conditions (7 self-reported mental conditions). Four medical conditions (osteoporosis, renal failure, varicose veins, and phlebitis) were dropped because of their very low prevalence reported by patients using VA ambulatory care. Two other medical conditions, arthritis and hip problems, were also excluded because of overlap with other arthritis questions. Four VHS study conditions (diabetes, hypertension, low back pain, and chronic obstructive lung disease/asthma) were added to the list of physical conditions because of their high prevalence in the veteran population (Table 1). With regard to the list of mental conditions, 6 of the 7 original MHQ mental items were included. The item "Other mental conditions" was dropped because it is nonspecific. Using these 2 lists, we developed a physical CI that included 30 self-reported physical conditions and a mental CI that included 6 self-reported mental conditions (see Appendix A).

Next, we made a separate list of medical conditions and their corresponding symptoms (see Appendix B). We created a combined CI with conditions and symptoms (condition/symptom CI) by substituting symptoms for corresponding conditions when available (see Appendix C).

We scored the physical and mental CIs by unweighted summation of the items. A summary score (the combined physical/mental CI) was generated by simple addition of the physical and mental CIs scores. We scored the symptom/condition CI in the same fashion. This unweighted strategy was adopted because we did not find any benefits using either a clinical or an empirical weighting system in preliminary analyses (data not shown).

There were no more than 5% missing data for any of the indexes. The proportion of patients with more than 1 missing response was 3.9% for physical CI, 0.9% for mental CI, and 3.9% for symptom/condition CI. For analysis, we used 1916 subjects who had complete data for all variables. We compared the sociodemographic characteristics and the number of comorbid conditions and found no significant differences among subjects with complete and incomplete data sets, except for race (a greater proportion of those who were white had complete data for all variables).

Table 1. Prevalence of medical and mental conditions

	%
Medical conditions	
1. High blood pressure	41.2
2. Enlarged prostate	29.4
3. Chronic low-back pain	23.6
4. Peptic ulcer	22.7
5. Irregular heartbeat	21.5
6. Osteoarthritis	21.1
7. Angina pectoris	20.2
8. Heart attack	18.7
9. Diabetes	17.5
10. Chronic lung disease	14.5
11. Gout	14.3
12. Cancer	13.5
13. Cataract	12.7
14. Gallbladder disease	11.4
15. Rheumatoid arthritis	10.8
16. Skin cancer	10.5
17. Peripheral vascular disease	10.1
18. Inflammatory bowel disease	8.4
19. Diverticulitis	8.0
20. Stroke	7.3
21. Congestive heart failure	5.8
22. Urinary tract infection	5.1
23. Hepatitis	4.9
24. Transient ischemic attacks	3.6
25. Seizure	3.5
26. Prostatitis	2.4
27. Osteoporosis	2.0
28. Renal failure	1.9
29. Thyroid disease	1.9
30. Phlebitis	1.1
Mental conditions	
1. Depression	29.7
2. Anxiety	19.7
3. Alcohol abuse	15.7
4. Posttraumatic stress disorder	11.1
5. Bipolar	6.9
6. Schizophrenia	4.8

Index validity

We evaluated how well each of the CIs correlated with HRQoL by calculating Pearson's product-moment correlations between the CIs and the SF-36 scores. We also examined the relationship between the CIs and the number of outpatient visits in the 6 months following the VHS baseline assessment. Data on outpatient visits were obtained by matching the VHS data with administrative data from the Austin Data Processing Center (DPC): "National VAMC Outpatient Care (OPC) File: Visits."

We applied ordinary least squares regression to ascertain the relative contribution of the different CIs in accounting for variation in HRQoL and outpatient clinic visits (Hamilton, 1992). We first examined the effects of the physical CI and the mental CI on the PCS, the MCS, and the outpatient visits in unadjusted models. Then, we adjusted for sociodemographic characteristics and disability rating to examine the effects of the physical CI and the mental CI on the PCS and MCS. In a separate model, using outpatient clinic visits as the dependent variable, we used the same covariates and added PCS and MCS as additional adjustments. Then, we substituted the condition/symptom CI for the physical CI and developed regression models in a similar fashion to examine the relative contribution of this index in accounting for variation in PCS, MCS, and outpatient clinic visits.

For the analysis of survival data, we used the Cox proportional hazard model. First, we examined the relationship between the CIs and survival (Cox & Dakes, 1984). Then, we adjusted these models for sociodemographics and disability rating. A final model was developed by adding the PCS and MCS scores from the SF-36.

RESULTS

Mirroring the VA outpatient population, about 50% of the patients were 65 years of age and older (mean = 64, SD = 12.7), 59% had less than high school education, and 51% had an annual income of $20,000 or less (Table 2). The mean number of chronic conditions was 6.3 (SD = 4.1). The more prevalent conditions included hypertension (41%), depression (30%), enlarged prostate (29%), chronic low-back pain (24%), peptic ulcer (23%), irregular heartbeat (22%), osteoarthritis (21%), angina pectoris (20%), anxiety (20%), heart

Table 2. Sociodemographic characteristics of 2425 VHS patients*

	Mean (SD) or %
Age, y	64 (12.7)
Race (white)	92
Marital status (married)	59
Education ≤ 12 y	59
Unemployed	67
Income ≤ $20,000 (annual household)	51
Disability rate ≥ 40	25

*VHS indicates Veterans Health Study.

attack (19%), diabetes (17.5%), and chronic lung disease (14.5%) (Table 1).

The relationship between the CIs and the HRQoL

Table 3 reports the correlations between the physical and mental CIs and the HRQoL. Both physical and mental CIs were significantly associated with all the SF-36 scales. The physical CI had the largest associations ($r \geq 0.29$) with the physical scales of the SF-36. In contrast, the mental CI correlated better ($r \geq 0.30$) with the mental scales of the SF-36. Furthermore, the physical and mental CIs correlated as well or better with the PCS and MCS (respectively) than did the combined physical/mental CI.

Compared with the physical CI, the condition/symptom CI had higher correlation coefficients with all the SF-36 scales and the PCS. In contrast, this index had weaker correlations with MH, RE, and MCS than did the mental CI. These findings were expected since the symptom/condition CI did not include mental conditions.

The linear regressions presented in Table 4 show the amount of variance in the PCS and MCS explained by the physical CI and the mental CI. In model 1a, we used the physical CI and the mental CI to predict the PCS score. The model explained 17% of the variance in the PCS. Only the regression coefficient of the physical CI was statistically significant. After adjusting for sociodemographics and disability rating, the amount of variance explained by the model increased to 24% (model 2a). Although the regression coefficients of both the physical CI and the mental CI were significant, the physical CI had a negative regression coefficient whereas the mental CI had a positive one. The opposite signs of these regression coefficients were most likely due to the

Table 3. Correlations between comorbidity indexes and HRQoL*

HRQoL (SF-36)†	Physical CI	Mental CI	Combined physical/ mental CI	Condition/ symptom CI
Physical functioning	−0.39	−0.11	−0.39	−0.48
Role limitations due to physical health	−0.29	−0.23	−0.35	−0.40
Bodily pain	−0.33	−0.22	−0.38	−0.47
General health	−0.39	−0.25	−0.45	−0.54
Vitality	−0.25	−0.36	−0.37	−0.43
Social functioning	−0.24	−0.40	−0.38	−0.40
Role limitations due to emotional problems	−0.12	−0.45	−0.29	−0.28
Mental health	−0.13	−0.57	−0.35	−0.32
Physical component summary (PCS)	−0.42	−0.04	−0.39	−0.50
Mental component summary (MCS)	−0.08	−0.57	−0.31	−0.39

*HRQoL indicates health-related quality of life; CI, comorbidity index.

†Scores range 0 to 100, with lower scores indicating worse functioning or quality of life. All correlation coefficients are statistically significant ($P < .05$) except for the correlation between mental CI and PCS.

Table 4. Regression results explaining the effects on PCS and MCS*

Explanatory variables	PCS regression coefficients				MCS regression coefficients			
	Model 1a	**Model 2a**	**Model 3a**	**Model 4a**	**Model 1b**	**Model 2b**	**Model 3b**	**Model 4b**
Physical CI	−1.77[†]	−1.71[†]			−0.18[‡]	−0.40[†]		
Mental CI	−0.11	0.63[§]	0.61[‖]	1.04[†]	−5.50[†]	−4.96[†]	−5.21[†]	−4.71[†]
Condition/ symptom CI			−1.87[†]	−1.70[†]			−0.61[†]	−0.69[†]
Age		0.13[†]		0.06[§]		0.19[†]		0.19[†]
Education		0.38[‖]		0.32[‖]		0.11		0.08
Race		1.28		0.79		1.41		1.16
Marital status		−1.03[‡]		−0.86		−1.21[‡]		−1.08[‡]
Income		1.10[‡]		0.93[‡]		0.74[†]		0.64[†]
Disability rate		−0.08[†]		−0.07[†]		−0.02[‡]		−0.01
Adjusted R^2	0.174	0.244	0.258	0.303	0.330	0.360	0.352	0.381

*PCS indicates physical component summary; MCS, mental component summary; and CI, comorbidity index.
[†] $P < .0001$.
[‡] $P < .05$.
[§] $P < .01$.
[‖] $P < .001$.

effect of the population sampling with high prevalence of psychiatric morbidities.

The amount of variance in the MCS explained by the physical and mental CIs was 33% (model 1b). After adjusting for sociodemographics and disability rating, the amount of variance explained increased slightly (36%) (model 2b). The regression coefficients of the physical CI and the mental CI were statistically significant and had the same directional association with the MCS.

When we substituted the condition/ symptom CI for the physical CI, the regression models explained 26% and 35% of the variance in the PCS (model 3a) and the MCS respectively (model 3b). After adjusting for sociodemographics and disability rating, the amount of variance explained in the PCS increased to 30% (model 4a) and in the MCS increased to 38% (model 4b).

The relationship between the CIs and utilization of resources

Table 5 presents the regression models that show the relative contribution of the physical CI and the mental CI to total outpatient clinic visits. The physical CI and the mental CI explained 5% of the variance (model 1a). Both indexes' regression coefficients were significant. After adjusting for sociodemographics and disability rating, the amount of variance explained in the outpatient visits by the physical CI and mental CI was 7% (model 2a). When we added the PCS and MCS to the model, the amount of variance explained was 8% (model 3a). The regression coefficients of physical CI, mental CI, PCS, and MCS were all significant. In contrast, the condition/symptom CI did not increase the amount of variance explained in the total outpatient clinic visits (models 1b through 3b).

The linear regression models presented in Table 6 show the amount of variance in the medical and mental outpatient clinic visits explained by the physical and mental CIs. The physical CI was a statistically significant predictor of medical outpatient clinic visits. In contrast, the mental CI was a significant predictor of mental outpatient visits. The amount of variance explained in the medical

Table 5. Regression results explaining the effects on total outpatient clinic visits*

Explanatory variables	Total outpatient clinic visits regression coefficients					
	Model 1a	Model 2a	Model 3a	Model 1b	Model 2b	Model 3b
Physical CI	0.16†	0.15†	0.10‡			
Mental CI	0.45§	0.36†	0.26§	0.40†	0.33†	0.26§
Condition/ symptom CI				0.15†	0.13†	0.06‖
Age		−0.01	0.00		−0.00	0.01
Education		−0.00	0.01		0.00	0.01
Race		−0.27	−0.20		−0.22	−0.18
Marital status		−0.19	−0.25		−0.20	−0.25
Income		−0.15‡	−0.10‖		−0.14‡	−0.10‖
Disability rate		0.01†	0.07‡		0.01†	0.01‡
PCS			−0.03†			−0.03§
MCS			−0.02§			−0.02‡
Adjusted R^2	0.054	0.066	0.077	0.057	0.067	0.075

*CI indicates comorbidity index; PCS, physical component summary; and MCS, mental component summary.
†$P < .0001$.
‡$P < .01$.
§$P < .001$.
‖$P < .05$.

(model 1a) and mental outpatient visits (model 1b) was 3% and 14% respectively. After adjusting for sociodemographics and disability rating, the regression coefficients of the physical CI and the mental CI remained statistically significant for predicting medical (model 2a) and mental outpatient visits (model 2b) respectively. In these adjusted models, the amount of variance explained in medical and mental outpatient visits remained about the same. In adding the PCS and the MCS to these models, we found the PCS and the physical CI to be significant predictors of medical outpatient visits (model 3a). Similarly, the MCS and the mental CI were significant predictors of mental outpatient visits (model 3b). The amount of variance explained in medical and mental outpatient visits increased slightly, up to 5% and 16%, respectively. In contrast, the condition/ symptom CI did not increase the amount of variance explained in the medical outpatient clinic visits (models 4a through 6a) and mental outpatient visits (models 4b through 6b).

Survival analysis

The cumulative frequency of death during a 35-week period was 77 study subjects (4%) out of 1947 VHS participants for which we had dispositions. Using the physical CI in a Cox proportional hazard model, patients were 14% more likely to die for each additional unit in the physical CI (Table 7). When mental CI was added to the model, it was not statistically significant (model 2). After adjusting for sociodemographics and disability rating (model 3), the risk of dying for every increment in the physical CI was 9%. However, after adjusting for PCS and MCS (model 4), neither CI remained statistically significant. When we substituted the condition/symptom CI for the physical CI, we obtained similar results (models 5–8).

DISCUSSION

We developed 2 short CIs, the physical CI and the mental CI. They had medical history

Table 6. Regression results explaining the effects on medical and mental outpatient clinic visits*

	Medical outpatient clinic visits regression coefficients						Mental outpatient clinic visits regression coefficients					
Explanatory variables	**Model 1a**	**Model 2a**	**Model 3a**	**Model 4a**	**Model 5a**	**Model 6a**	**Model 1b**	**Model 2b**	**Model 3b**	**Model 4b**	**Model 5b**	**Model 6b**
Physical CI	0.18†	0.16†	0.11†				−0.02	−0.01	−0.02			
Mental CI	0.04	−0.23	−0.04	−0.01	−0.05	−0.05	0.40†	0.38†	0.31†	0.41†	0.38†	0.31†
Condition/Symptom CI				0.16†	0.13†	0.09‡				0.01	−0.01	−0.02‖
Age		−0.00	0.00		0.01	0.01		−0.01‖	−0.00		−0.01§	−0.00
Education		−0.01	−0.00		−0.01	−0.00		0.01	0.01		0.01	0.01
Race		−0.36	−0.32		−0.33	−0.31		0.10	0.13		0.10	0.12
Marital status		−0.15	−0.19		−0.16	−0.19		−0.04	−0.06		−0.04	−0.06
Income		−0.11§	−0.07		−0.10‖	−0.07		−0.04‖	−0.03		−0.04‖	−0.03
Disability rate		0.01†	0.01‡		0.01†	0.01‡		0.00	−0.00		0.00	−0.00
PCS			−0.03†			−0.03†			−0.00			−0.00
MCS			−0.01			−0.01			−0.02†			−0.02†
Adjusted R^2	0.033	0.046	0.055	0.034	0.046	0.053	0.144	0.146	0.158	0.143	0.146	0.159

*CI indicates comorbidity Index; PCS, physical component summary; and MCS, mental component summary.
† $P < .0001$.
‡ $P < .001$.
§ $P < .01$.
‖ $P < .05$.

Table 7. Cox proportional hazards models of survival*

	Parameter estimates							
Explanatory variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
Physical CI	0.142†	0.146†	0.092‡	0.032				
Mental CI		−0.075	−0.071	−0.086		−0.122	−0.095	−0.085
Condition/ symptom CI					0.119†	0.131†	0.090§	0.030
Age			0.024‡	0.032			0.029‖	0.033‖
Education			0.003	0.016			0.003	0.016
Race			−0.242	−0.153			−0.206	−0.150
Marital status			0.004	−0.032			−0.015	−0.035
Income			−0.191‡	−0.145			−0.177	−0.143
Disability rate			0.0120§	0.007‡			0.010§	0.0075
PCS				−0.040‖				−0.037‖
MCS				−0.011				−0.010
Pseudo R^2	1.46	1.52	3.05	4.04	1.37	1.54	3.20	4.40

*CI indicates comorbidity index; PCS, physical component summary; and MCS, mental component summary.
†$P < .0001$.
‡$P < .05$.
§$P < .001$.
‖$P < .01$.

questions that could be readily administered in ambulatory settings where medical records are often incomplete. An important benefit of having 2 indexes, a physical CI and a mental CI, was that they were distinctively related to different aspects of HRQoL, as well as to outpatient clinic visits. The physical CI and the mental CI not only correlated better with the physical scales and the mental scales of the SF-36 (respectively) than did the combined physical/mental CI, but also contributed independently in explaining the variability of SF-36 scales. In addition, the physical and mental CIs also contributed independently to explain the variability of both medical and mental outpatient clinic visits. Even after controlling for physical and mental status (PCS and MCS), the indexes remained significant predictors of utilization of resources. These findings indicate that the separation of conditions into 2 components is useful and that such a strategy can supplement other health status measures.

Compared to the original DBI that we developed earlier in the VHS, we had 2 indexes that made possible finer examinations of the different ways that physical and mental comorbid conditions affect HRQoL and utilization of resources. For example, substitution of the physical and mental CIs for the DBI resulted in increased explanatory power for predicting MCS. The R^2 of the regression model increased from 15% to 33% and the regression coefficients increased from −1.32 to −5.50 ($P < .0001$ for both comparisons, results not shown). We encountered similar results when number of mental outpatient clinic visits was the outcome of interest (eg, $R^2 = 2.3\%$ vs 14% and coefficients 0.06 vs 0.40; both $P < .0001$).

We also explored the development of a "mixed" CI by substituting symptoms for their corresponding conditions in the CI where available, creating the condition/symptom CI. The result was a CI that had a greater association with HRQoL than did the one that used diagnoses alone. This finding is consistent with the concept that much of the variation in HRQoL is associated with symptoms. In contrast, the condition/symptom CI offered no advantage in predicting utilization of resources or survival. However, the fact that performance is unimpaired in relation to utilization of resources and survival means that one might be able to develop a CI that is wholly symptom-based instead of using a comprehensive list of conditions. This would have the benefit of assessing illness burden on the basis of a selected set of common symptoms, something that would take advantage of the fact that organ systems have a limited number of ways that they can manifest a broad variety of conditions.

Although we assume that there is a relationship among patient characteristics, health outcomes, and frequency of outpatient visits, our findings show that the majority of variance in predicting outpatient visits cannot be explained by the mental CI and the physical CI. A possible interpretation of the unexplained variance is that access and organizational factors, such as patients/clinical staff ratio, next available appointment, part-time vs full-time staff, and types of providers, may have an important impact on the determination of the return to outpatient clinic visits. It may be that the revisit interval may be predominantly physician or system driven.

The accuracy of our CI in identifying medical and psychiatric conditions is supported by external data. We compared the prevalence of conditions reported in our study with that in the National Survey of Veterans (1995). The frequency of occurrence of chronic conditions in the 2 studies corresponded reasonably well. For example, the prevalence of hypertension in the VHS and the National Survey of Veterans was 41% and 45%, chronic lung problems 14.5% and 16.3%, and diabetes 17.5% and 13.2%, respectively.

We should note 2 limitations of this study. First, the testing of the CI was performed in a population predominantly of elderly male veterans receiving ambulatory care in VA settings. Further evaluations of the CI are needed in more diverse populations. Second, our analyses utilized self-reported data about diagnoses, which may be biased because of recall error (Bergmann et al., 1998). However, studies have validated self-reported diagnosis with different sources of physician-made diagnosis, such as medical records and administrative databases (Bergmann et al., 1998; katz et al., 1996; Robinson et al., 1997). They have shown that self-reports of chronic conditions were a valid source of information (Skinner et al., in press). Therefore, we aimed with the CI index to obtain the level and kind of detailed clinical information that can be derived directly from the patient by using an inclusive list of medical and psychiatric conditions administered by a technician trained by physicians.

Our patient-based assessment of comorbidity appears to be a practical approach that is easy to use in the outpatient setting. In contrast to methods based on medical record audit, these indexes have the advantage of ease of use in ambulatory populations of large-scale observational studies. Having 2 components may prove useful in exploring the extent to which medical and mental conditions affect different aspects of HRQoL and utilization of resources. Our physical and mental CIs may be particularly valuable for clinicians and researchers interested in population-based studies, case-mix adjustment, and clinical trials. Furthermore, our findings lend support to the possibility of developing a wholly symptom-based measure that might be still shorter and that could have an enhanced relationship with HRQoL, while maintaining predictive power for utilization of resources and mortality.

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Appendix A
Comorbidity Index

PHYSICAL CI (CONDITIONS ONLY)

1. Dx of cataracts
2. Dx of angina pectoris
3. Dx of heart attack
4. Dx of congestive heart failure
5. Dx of irregular heartbeat
6. Dx of peptic ulcer
7. Dx of inflammatory bowel disease
8. Dx of diverticulitis
9. Dx of chronic hepatitis or cirrhosis
10. Dx of gallbladder disease or gallstones
11. Dx of urinary tract infection
12. Dx of enlarged prostate
13. Dx of prostatitis
14. Dx of osteoarthritis
15. Dx of rheumatoid arthritis
16. Dx of gout
17. Dx of other arthritis
18. Dx of hip problems
19. Dx of cancer
20. Dx of skin cancer
21. Dx of peripheral vascular disease
22. Dx of seizure disorder
23. Dx of stroke
24. Dx of transient ischemic attacks
25. Dx of thyroid disease
26. Dx of anemia
27. Dx of diabetes mellitus
28. Dx of hypertension
29. Dx of low back pain
30. Dx of chronic obstructive lung disease/ asthma

(4 items were dropped: osteoporosis, renal failure, varicose veins, and phlebitis)

MENTAL CI

1. Dx of schizophrenia
2. Dx of depression
3. Dx of bipolar disorder
4. Dx of anxiety disorder
5. Dx of posttraumatic stress disorder
6. Dx of alcohol abuse

(1 item was dropped: other mental disorders)

Appendix B

Diagnoses and Corresponding Symptoms

DIAGNOSES

1. Dx of cataracts
2. Dx of angina pectoris
4. Dx of congestive heart failure
6. Dx of peptic ulcer
7. Dx of inflammatory bowel disease
8. Dx of diverticulitis
10. Dx of gallbladder disease or gallstones
13. Dx of enlarged prostate
23. Dx of peripheral vascular disease
27. Dx of transient ischemic attack
30. Dx of chronic obstructive lung disease/ asthma

SYMPTOMS

2. Visual blurring (Dx #1)
4. Cough (Dx #30)
6. Chest pain (Dx #2)
7. Shortness of breath (Dx #4 and #30)
8. Peptic pain (Dx #6)
9. Abdominal pain (Dx #7, 8, 10)
11. Diarrhea repeatedly during last 6 months (Dx #7)
13. Nocturia (Dx #13)
15. Intermittent claudication (Dx #23)
16. Leg swelling (Dx #4)
23. Transient ischemic attacks symptoms (Dx #27)

Appendix C

Condition/Symptom Physical CI: Conditions and Symptoms Minus Diagnoses With Concordant Symptoms

1. Visual blurring
2. Cough
3. Chest pain
4. Shortness of breath
5. Dx of heart attack
6. Dx of irregular heartbeat
7. Peptic pain
8. Abdominal pain
9. Diarrhea repeatedly during past 6 months
10. Dx of chronic hepatitis or cirrhosis
11. Dx of urinary tract infection
12. Nocturia
13. Dx of prostatitis
14. Dx of osteoarthritis
15. Dx of rheumatoid arthritis
16. Dx of gout
17. Dx of other arthritis
18. Dx of hip problems
19. Dx of cancer
20. Dx of skin cancer
21. Dx of peripheral vascular disease
22. Leg swelling
23. Dx of seizure disorder
24. Dx of stroke
25. Transient ischemic symptoms
26. Dx of thyroid disease
27. Dx of anemia
28. Dx of diabetes mellitus
29. Dx of hypertension
30. Dx of low back pain