Validating the Adapted Diabetes Complications Severity Index in Claims Data

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Objectives: To test the validity of the adapted Diabetes Complications Severity Index (aDCSI), which does not include laboratory test results, as an indicator of diabetes severity.

Study Design: Retrospective cohort study using 4 years of claims data from 7 health insurance plans.

Methods: Individuals with diabetes mellitus and continuous enrollment were study subjects (N = 138,615). The 2 independent variables—the aDCSI score (sum of 7 diabetes complications graded by severity as 0, 1, or 2; range 0-13) and the aDCSI diabetes complication count (sum of 7 diabetes complications without severity grading; range 0-7)—were generated using only claims data. We evaluated the numbers of hospitalizations attributable to the aDCSI with Poisson regression models, both categorically and linearly.

Results: The aDCSI score (risk ratio 1.39 to 6.10 categorically and 1.41 linearly) and diabetes complication count (risk ratio 1.67 to 9.11 categorically and 1.65 linearly) were both significantly positively associated with the number of hospitalizations over a 4-year period. Risk ratios from the aDCSI score were very similar to the risk ratios previously reported for the Diabetes Complications Severity Index (DCSI); the absolute difference between risk ratios ranged from 0.01 to 1.6 categorically and was 0.05 linearly.

Conclusions: The aDCSI is a good measure of diabetes severity, given its ability to explain hospitalizations and its similar performance to the DCSI.

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For author information and disclosures, see end of text.

Diabetes mellitus is one of the major healthcare issues in the United States because of its high prevalence and the growing costs of caring for affected patients.[1-3] Complications associated with diabetes drive the escalating costs of diabetes management. Although several risk measures were developed to quantify the severity of diabetes complications, they mostly targeted a specific condition instead of the broad array of diabetes complications.[4-6] The Diabetes Complications Severity Index (DCSI), developed by Young and colleagues, uniquely incorporates a wide range of diabetes complications.[7]

The DCSI incorporates diagnosed complications along with select laboratory results to assess patients' risks of adverse outcomes, including hospitalizations and death. It uses information from 7 diabetes complication categories.[7] Even though the DCSI is a relatively new measure, it has been quickly adopted by researchers.[8-12] However, DCSI's utility as a risk measure to characterize a diabetic population may be limited because laboratory test results are not readily available to researchers, particularly those who rely on administrative claims.

Risk measures have increasingly relied on claims data because they are inexpensively available for a great number of individuals; these data include claims for diagnoses and procedures and often information on dispensed medications.[13,14] One widely used risk adjustment measure, the Adjusted Clinical Group system, uses an individual's diagnoses and pharmacy data from 1 year to assign a morbidity level.[15] This approach has been validated both domestically[16] and internationally.[17,18] However, claims data usually do not include laboratory information, which makes it difficult for risk measures that require laboratory results to be applied on a large scale.

Therefore, our purpose was to test the validity of the adapted Diabetes Complications Severity Index (aDCSI), which excludes laboratory test results, as an indicator of diabetes severity. We hypothesized that the aDCSI would be comparable to the DCSI (which includes laboratory data) and be a good measure of diabetes severity.

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RESEARCH DESIGN AND METHODS

Design

This was a retrospective cohort study using 4 years of claims data in

Take-Away Points

The adapted Diabetes Complications Severity Index (aDCSI), which does not include laboratory test results, is a good measure of diabetes severity.

- The aDCSI was significantly positively associated with the number of hospitalizations over a 4-year period.
- Risk ratios of hospitalizations based on the aDCSI score were similar to risk ratios from the DCSI, which does include laboratory data.
- The aDCSI has yet to be validated against mortality, which is the major limitation of this study.

which we tested the value of the aDCSI for explaining the number of hospitalizations.

Data

We accessed claims data from 7 Blue Cross Blue Shield plans; the detailed information was described in a published paper.[19] The original data were collected from 2002 to 2005; the data were subsequently updated with additional data on the original individuals through 2006. The following data were acquired: (1) enrollment files for administrative data; (2) benefits information to determine medical and pharmacy coverage; and (3) inpatient, outpatient, and pharmacy claims records containing the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) diagnosis, Current Procedural Terminology codes, and National Drug Code prescription information.

Defining the Analytic Cohort

We required that the enrollees have type 2 diabetes, and full medical and pharmacy coverage in the 4-year period.

We defined individuals as having type 2 diabetes if they had 1 relevant inpatient code or 2 outpatient *ICD-9-CM* codes separated by at least 30 days. The relevant codes were 250 .xx, 648.0 (diabetes mellitus with pregnancy), and 362.0 (diabetic retinopathy) or 266.41 (diabetic cataract). Individuals only with 250.x3 (type 1 diabetes) were not included. Additionally, any individual filling a prescription for a medication for treatment of hyperglycemia was included (**eAppendix A**, available at **www.ajmc.com**). Combination medications were also identified. If the prescription was for metformin alone, the individual was also required to have an *ICD-9-CM* code for diabetes for inclusion in this group. The calendar year of the earliest diagnosis of diabetes was used as the starting point of the observation period.

Number of Hospitalizations and Costs

The number of hospitalizations was obtained from the inpatient claims over a 4-year period. Costs were obtained from the claims over a 4-year period; per person per year total costs and pharmacy costs were presented. Total costs were examined as well as pharmacy costs.[20]

DCSI Scores and DCSI Complication Counts

To replicate the DCSI scores and DCSI complication counts, we identified the claims coded with the *ICD-9-CM* system for individuals during the 4-year study period and applied the classification method developed by Young and colleagues (**eAppendix B**).[7] The DCSI *score* consists of scores (0, 1, or 2) from 7 complication categories: retinopathy, nephropathy, neuropathy, cerebrovascular, cardiovascular, peripheral vascular disease, and metabolic; it ranges from 0 to 13. The DCSI *complication count* is a count of any complication in the 7 categories and ranges from 0 to 7. We did not include laboratory results in constructing these aDCSI scores and aDCSI complication counts.

Statistical Methods

For number of hospitalizations, we adopted a Poisson model with adjustment for overdispersion, to parallel what Young and colleagues did. Given that there were many people without any hospitalizations, a zero-inflated negative binomial model was also used for a sensitivity analysis. The patterns of results from both models were similar, so we just report the results from the Poisson model.

We calculated risk ratios for hospitalization. We tested inclusion of the main independent variables, aDCSI score and aDCSI complication count, categorically (0, 1, 2, 3, 4, 5+) and linearly. In categorical analysis, the risk ratio of hospitalizations was derived by comparing samples in a given category with those in category 0; in linear analysis, it was the risk ratio of hospitalizations associated with a 1-unit increase in aDCSI score.

Comparison of DCSI With and Without Laboratory Test Results

We compared the risk ratios of hospitalizations obtained in this study with those in the study by Young et al to determine whether the aDCSI (without laboratory information) and the DCSI (with laboratory information) perform similarly. Given the differences in study population and sample size, we decided that if the risk ratios from both sources were similar and showed similar patterns across risk groups, we would conclude that the aDCSI and DCSI performed similarly.

Review

The data were deidentified in accordance with the Health Insurance Portability and Accountability Act's definition of a limited data set. The Johns Hopkins University Office of Research Subjects deemed the study to be exempt from federal regulations because the research activities were considered to

be of minimal risk to subjects, as they were not identifiable.

RESULTS

Characteristics of the Study Samples

There were 138,615 study subjects (Table 1). The mean age was about 59 years and roughly 51% were male. About 70% of the study subjects had a score of 0 for DCSI score/complication count, and close to 60% had no hospitalization. The mean aDCSI score, aDCSI complication count, and number of hospitalizations were 0.50, 0.37, and 0.94, respectively. The average annual total cost was $11,500 over a 4-year period, of which $3000 (26%) was pharmacy cost.

Table 1. Characteristics of Study Sample (N = 138,615)

Characteristic	Value
Age, y, mean ± SD[a]	58.6 ± 12.4
Male[a]	50.66%
aDCSI score (0-13)	
Mean ± SD	0.50 ± 0.98
0	71.67%
1	14.71%
2	8.73%
3	2.71%
4	1.35%
5+	0.83%
aDCSI complication count (0-7)	
Mean ± SD	0.37 ± 0.65
0	71.67%
1	21.55%
2	5.18%
3	1.27%
4	0.28%
5+	0.05%
Hospitalization	
Mean ± SD	0.94 ± 1.80
0	57.86%
1	21.32%
2	9.54%
3	4.70%
4	2.70%
5+	4.07%
Costs per person per year over a 4-year period	
Total costs ± SD	$11,371 ± $14,592
Pharmacy costs ± SD	$2940 ± $3222

aDCSI indicates adapted Diabetes Complications Severity Index; SD, standard deviation.
[a]0.2% had missing data on age and sex.

With Laboratory Versus Without Laboratory

Without laboratory data, aDCSI score and aDCSI complication count were significantly positively associated with the number of hospitalizations over a 4-year period. Categorically, risk ratios ranged from 1.39 to 6.10 for aDCSI score and from 1.67 to 9.11 for aDCSI complication count, when comparing the non-zero categories (from 1 to 5+) with the category 0. Linearly, the risk ratio was 1.41 for each 1-unit increase in aDCSI score and 1.65 for each additional aDCSI complication count (Table 2).

Compared with the DCSI with laboratory data used by Young et al,[7] risk ratios for hospitalization as determined by aDCSI score were very similar when the score was less than or equal to 3, and a little lower when the score was above 3 (Figure). The absolute difference in risk ratios between our results and those of Young et al increased as the score category increased, ranging from 0.01 to 1.6. Linearly, the risk ratio for aDCSI score was a little higher than that for DCSI score (1.41 vs 1.36). Similar patterns were observed using the DCSI complication count (Table 2).

DISCUSSION

We found that even without inclusion of laboratory test results, the aDCSI can be used to explain hospitalization. The similarities of the risk ratios determined by the DCSI with and without laboratory results suggest that the DCSI might be applied when laboratory data are not available.

Removing the requirement of including laboratory results will expand the usefulness of the DCSI. Claims data are routinely collected by health insurers for the purpose of reimbursement. Many health-related measures have been constructed using only the information in claims so that these measures can be applied widely.

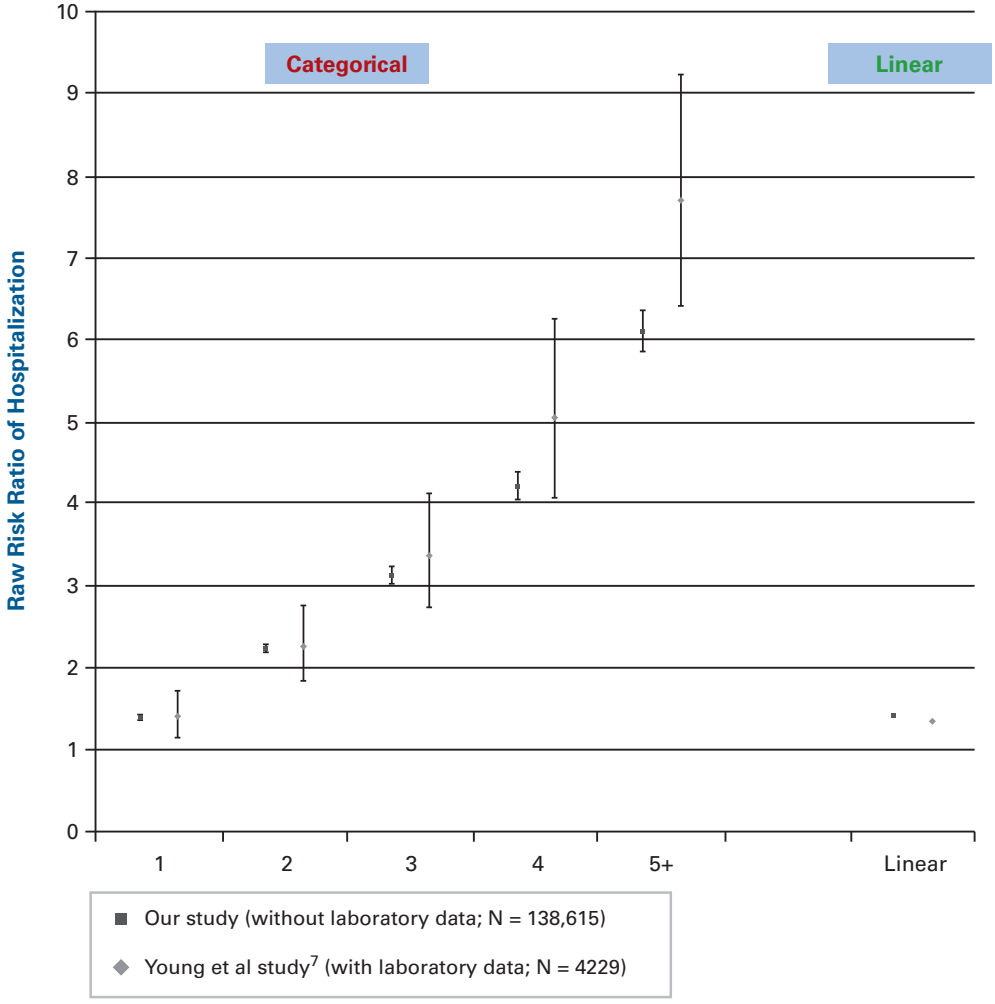
In this study we compared risk ratios derived from 2 different data sets. Differences existed between these 2 samples;

Table 2. Comparison of Risk Ratios of Hospitalization With and Without Laboratory Data by Main Predictors

Main Predictor	aDCSI/DCSI Score		aDCSI/DCSI Complication Counts	
Source	Our study (N = 138,615)	Young et al study[7] (N = 4229)	Our study (N = 138,615)	Young et al study[7] (N = 4229)
Laboratory data	No	Yes	No	Yes
Categorical analysis, risk ratio (95% CI)[a]				
1	1.39 (1.36-1.42)	1.40 (1.14-1.72)	1.67 (1.64-1.70)	1.65 (1.36-2.00)
2	2.24 (2.19-2.29)	2.25 (1.84-2.76)	2.97 (2.90-3.04)	2.81 (2.27-3.41)
3	3.13 (3.03-3.23)	3.36 (2.72-4.14)	4.48 (4.31-4.66)	4.61 (3.78-5.63)
4	4.21 (4.05-4.37)	5.05 (4.07-6.26)	6.40 (5.98-6.84)	6.47 (5.24-8.00)
5+	6.10 (5.86-6.36)	7.70 (6.41-9.24)	9.11 (8.02-10.35)	10.61 (8.38-13.42)
Linear analysis, risk ratio (95% CI)	1.41 (1.40-1.41)	1.36 (1.34-1.39)		

aDCSI indicates adapted Diabetes Complications Severity Index; CI, confidence interval; DCSI, Diabetes Complications Severity Index.
[a]Category 0 was the reference group.

Figure. Point Estimate and 95% Confidence Intervals of Risk Ratio of Hospitalization Determined by aDCSI Score (Without Laboratory Data) and DCSI Score (With Laboratory Data)



aDCSI indicates adapted Diabetes Complications Severity Index; DCSI, Diabetes Complications Severity Index.

compared with our sample, the sample used by Young and colleagues[7] was much smaller (4229 vs 138,615), was older (63 vs 59 years), and had slightly more men (51.8% vs 50.7%). Additionally, their population had more diabetes complications (32%, 32%, and 36% had 0, 1, and 2+ complications vs 72%, 22%, and 6% in our study) and had a higher mean DCSI score (1.74 vs 0.50). These differences may be partially explained by exclusion of individuals with type 1 diabetes from our sample. Despite these differences, the risk ratios of hospitalization from both samples were comparable.

The important difference in sample size resulted in the much smaller 95% confidence intervals for both DCSI score and complication count across all levels (Table 2). In addition, the large disparity in comorbidity between the 2 samples might have contributed to the larger difference in risk ratios for the 5+ category that we observed between 2 studies. Young and colleagues' study population included more patients with 2 or more complications (36.4%) than our study population did (6.8%). We suspect that the patients in the Young et al study who had 5 or more complications were sicker than ours (eg, had 8 or 9 complications) within that category. Combined with the observation that the magnitude of risk ratio increased as the DCSI score and complication count increased, their risk ratio was higher than ours.

Our study had several potential limitations. First, this data set did not contain the laboratory data. Ideally, the comparison of the performance between the DCSI and aDCSI would have been made using information from the same study subjects. However, given the lack of laboratory data, this could not be done. Second, the mortality information was not available in our data. In the study by Young et al, the relationship between mortality and the DCSI was also examined. If this relationship could also be explored, that would further strengthen the conclusion that the aDCSI performs as well as the DCSI with laboratory data. Furthermore, the DCSI might be further refined using the pharmacy information included in claims data. Inclusion of this information might enable the DCSI to even better predict an individual's risk of hospitalization or death, and provide an estimate of the severity of his/her diabetes.

CONCLUSIONS

The aDCSI, which does not include laboratory data, is a good measure of diabetic severity, given its ability to explain hospitalizations and its similar performance to the DCSI, which does include laboratory results.

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REFERENCES

1. Beckles GL, Zhu J, Moonesinghe R; Centers for Disease Control and Prevention (CDC). Diabetes—United States, 2004 and 2008. *MMWR Surveill Summ.* 2011;60(suppl):90-93.

2. American Diabetes Association. Economic costs of diabetes in the U.S. in 2007 [published correction appears in *Diabetes Care.* 2008;31(6):1271]. *Diabetes Care.* 2008;31(3):596-615.

3. Roehrig C, Miller G, Lake C, Bryant J. National health spending by medical condition, 1996-2005. *Health Aff (Millwood).* 2009;28(2):w358-w367.

4. Stevens RJ, Kothari V, Adler AI, Stratton IM; United Kingdom Prospective Diabetes Study (UKPDS) Group. The UKPDS risk engine: a model for the risk of coronary heart disease in type II diabetes (UKPDS 56) [published correction appears in *Clin Sci (Lond).* 2002;102(6):679]. *Clin Sci (Lond).* 2001;101(6):671-679.

5. Selby JV, Karter AJ, Ackerson LM, Ferrara A, Liu J. Developing a prediction rule from automated clinical databases to identify high-risk patients in a large population with diabetes. *Diabetes Care.* 2001;24(9):1547-1555.

6. Clarke PM, Gray AM, Briggs A, et al; UK Prospective Diabetes Study (UKDPS) Group. A model to estimate the lifetime health outcomes of patients with type 2 diabetes: the United Kingdom Prospective Diabetes Study (UKPDS) Outcomes Model (UKPDS no. 68). *Diabetologia.* 2004;47(10):1747-1759.

7. Young BA, Lin E, Von Korff M, et al. Diabetes complications severity index and risk of mortality, hospitalization, and healthcare utilization. *Am J Manag Care.* 2008;14(1):15-23.

8. Ludman EJ, Russo JE, Katon WJ, et al. How does change in depressive symptomatology influence weight change in patients with diabetes? observational results from the Pathways longitudinal cohort. *J Gerontol A Biol Sci Med Sci.* 2010;65(1):93-98.

9. Maciejewski ML, Liu CF, Fihn SD. Performance of comorbidity, risk adjustment, and functional status measures in expenditure prediction for patients with diabetes. *Diabetes Care.* 2009;32(1):75-80.

10. Katon W, Russo J, Lin EH, et al. Diabetes and poor disease control: is comorbid depression associated with poor medication adherence or lack of treatment intensification? *Psychosom Med.* 2009;71(9):965-972.

11. Ciechanowski P, Russo J, Katon WJ, et al. Relationship styles and mortality in patients with diabetes. *Diabetes Care.* 2010;33(3):539-544.

12. Katon WJ, Lin EH, Williams LH, et al. Comorbid depression is associated with an increased risk of dementia diagnosis in patients with diabetes: a prospective cohort study. *J Gen Intern Med.* 2010;25(5):423-429.

13. Winkelman RA. *A Comparative Analysis of Claims-Based Tools for Health Risk Assessment.* http://www.soa.org/research/research-projects/health/hlth-risk-assement.aspx. Published April 20, 2007. Accessed July 8, 2009.

14. Ellis RP, Ash A. Refinements to the Diagnostic Cost Group (DCG) model. *Inquiry.* 1995;32(4):418-429.

15. Starfield B, Weiner J, Mumford L, Steinwachs D. Ambulatory care groups: a categorization of diagnoses for research and management. *Health Serv Res.* 1991;26(1):53-74.

16. Weiner JP, Starfield BH, Steinwachs DM, Mumford LM. Development and application of a population-oriented measure of ambulatory care case-mix. *Med Care.* 1991;29(5):452-472.

17. Chang HY, Weiner JP. An in-depth assessment of a diagnosis-based risk adjustment model based on national health insurance claims: the application of the Johns Hopkins Adjusted Clinical Group case-mix system in Taiwan. *BMC Med.* 2010;8:7.

18. Chang HY, Lee WC, Weiner JP. Comparison of alternative risk adjustment measures for predictive modeling: high risk patient case finding using Taiwan's National Health Insurance claims. *BMC Health Serv Res.* 2010;10:343.

19. Clark JM, Chang HY, Bolen SD, Shore AD, Goodwin SM, Weiner JP. Development of a claims-based risk score to identify obese individuals. *Popul Health Manag.* 2010;13(4):201-207.

20. Chang HY, Weiner JP, Richards TM, Bleich SN, Segal JB. Predicting costs with diabetes complications severity index in claims data. *Am J Manag Care.* 2012;18(4):213-219. ■

eAppendix A. Medications for Treatment of Diabetes

Oral Medications	**Insulins**
Acarbose	Insulin aspart
Chlorpropamide	Insulin detemir
Glimepiride	Insulin glargine
Glipizide	Insulin glulisine
Glyburide	Insulin human inhaled
Metformin	Insulin human isophane
Miglitol	Insulin regular
Nateglinide	Insulin lispro
Pioglitazone	
Pramlintide	
Repaglinide	
Rosiglitazone	
Sitagliptin	
Tolazamide	
Tolbutamide	
Other injectable	
Exenatide	

eAppendix B. Adapted Diabetes Complications Index and List of Complications Developed From *ICD-9-CM* Codes[a]

Complication and *ICD-9-CM* Diagnosis	***ICD-9-CM* Code**	**aDCSI Score[b]**	
		1	**2**
Retinopathy			
Diabetic ophthalmologic disease	250.5x	•	
Background retinopathy	362.01	•	
Other retinopathy	362.1	•	
Retinal edema	362.83	•	
CSME	362.53	•	
Other retinal disorders	362.81, 362.82	•	
Proliferative retinopathy	362.02		••
Retinal detachment	361.xx		••
Blindness	369.xx .00-.99		••
Vitreous hemorrhage	379.23		••
Nephropathy			
Diabetic nephropathy	250.4	•	
Acute glomerulonephritis	580	•	
Nephrotic syndrome	581	•	
Hypertension, nephrosis	581.81	•	
Chronic glomerulonephritis	582	•	
Nephritis/nephropathy	583	•	
Chronic renal failure	585		••
Renal failure NOS	586		••
Renal insufficiency	593.9		••
Neuropathy			
Diabetic neuropathy	356.9, 250.6	•	
Amyotrophy	358.1	•	
Cranial nerve palsy	951.0, 951.1, 951.3	•	
Mononeuropathy	354.0-355.9	•	
Charcot's arthropathy	713.5	•	

Polyneuropathy	357.2	•	
Cerebrovascular			
TIA	435	•	
Stroke	431, 433, 434, 436		••
Cardiovascular			
Atherosclerosis	440.xx	•	
Other IHD	411	•	
Angina pectoris	413	•	
Other chronic IHD	414	•	
Myocardial infarction	410		••
Ventricular fibrillation, arrest	427.1, 427.3		••
Cardiovascular			
Atrial fibrillation, arrest	427.4, 427.5		••
Other ASCVD	429.2	•	
Old myocardial infarction	412		••
Heart failure	428		••
Atherosclerosis, severe	440.23, 440.24		••
Aortic aneurysm/dissection	441		••
Peripheral vascular disease			
Diabetic PVD	250.7	•	
Other aneurysm, LE	442.3	•	
PVD	443.81, 443.9	•	
Foot wound + complication	892.1	•	
Claudication, intermittent	443.9	•	
Embolism/thrombosis (LE)	444.22		••
Gangrene	785.4		••
Gas gangrene	0.4		••
Ulcer of lower limbs	707.1		••
Metabolic			
Ketoacidosis	250.1		••
Hyperosmolar	250.2		••
Other coma	250.3		••

aDCSI indicates Adapted Diabetes Complications Severity Index; ASCVD, atherosclerotic cardiovascular disease; CSME, cystoid macular edema/degeneration; DCSI, Diabetes Complications Severity Index; IHD, ischemic heart disease; *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*; LE, lower extremity; NOS, not otherwise specified; PVD, peripheral vascular disease; TIA, transient ischemic attack.

[a]This table was adapted from the study by Young and colleagues,[7] in which the original DCSI was defined.

[b]Severity index was based on a scale ranging from 0 to 2 for each complication as follows: 0 = no abnormality, 1 = some abnormality, 2 = severe abnormality. Solid circle (•) indicates a count of 1 added to DCSI; double solid circle (••) indicates a count of 2 added to DCSI.