Diagnostic Cost Group Hierarchical Condition Category Models for Medicare Risk Adjustment

Final Report

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The Health Care Financing Administration (HCFA) implemented inpatient-based risk adjustment for a portion of capitation payments to Medicare + Choice (M+C) plans beginning January 1, 2000. The risk adjustment method used is the Principal Inpatient Diagnostic Cost Group or PIP-DCG model (Pope et al., 1999). Medicare is scheduled to transition to all-encounter-based risk adjustment in 2004. The all-encounter model will add information from hospital outpatient and physician encounters to information from inpatient encounter records. The all-encounter risk adjustment model within the Diagnostic Cost Group, or DCG, family of risk adjustment models is known as the Diagnostic Cost Group, Hierarchical Condition Category (DCG/HCC) model. This report describes the latest refinements and updates to the DCG/HCC model resulting from research funded by the Health Care Financing Administration.

The current project includes updates, refinements, and new research for the DCG/HCC models. The major updates to the DCG/HCC models were:

- recalibration of the model using 1996/1997 data (as compared to the 1991/92 data used in our previous projects);
- updating ICD-9-CM diagnosis codes to be current through FY 2000.

The major refinements to the model were:

- more clinically detailed diagnostic classification system;
- adjustments for the joint effect on expenditures of certain combinations of diagnoses;
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- more detailed adjustment for expenditure differences of beneficiaries entitled to Medicare by disability;
- calibration of Medicaid, originally disabled, and working aged demographic factors in conjunction with the updated DCG/HCC model.

The major research issues we investigated were:

- validity of the DCG/HCC model assumption that the predicted expenditures associated with multiple diagnoses are generally modeled accurately as the sum of the incremental expenditures predicted for each (individual) diagnosis.
- gain in predictive accuracy from incorporating additional sources of diagnoses, for example, diagnoses from home health agencies.
- use of durable medical equipment in risk adjustment.
- evaluation of the predictive accuracy of model variants for additional nonrandom groups of beneficiaries, such as beneficiaries with high home health expenditures.

Clinical Classification and Elements of Revised Model

Table ES-1 outlines the Diagnostic Cost Group clinical classification system. The more than 15,000 International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes are grouped into 804 diagnosis groups, or "DxGroups". The DxGroups are further aggregated into either the Principal Inpatient Diagnostic Cost Groups (PIP-DCG) or the Diagnostic Cost Group/Hierarchical Condition Category (DCG/HCC) clinical classifications. The PIP-DCG model utilizes only principal inpatient diagnoses, and classifies a beneficiary based on his or her single

---

1 The PIP-DCG model has not been updated to reflect the latest revision of the DxGroups developed for this project. The PIP-DCG classification is based on the previous DxGroups (n=545).
diagnosis that predicts the highest future expenditures. The PIP-DCG model is currently used to risk adjust a portion of Medicare+Choice capitation payments.

**Table ES-1**

**Diagnostic Cost Group Clinical Classifications**

The DCG/HCC mode l utilizes diagnoses from all physician and hospital encounters, and profiles beneficiary medical problems with diagnostic categories (HCCs) that are not mutually exclusive. A beneficiary's total predicted expenditure is the sum of the incremental predicted expenditures associated with each of his or her assigned HCCs.
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As part of this project, the number of DxGroups was increased from 545 to 804, and the number of HCCs (in the comprehensive classification system) was increased from 118 to 189.

The revised prospective DCG/HCC payment model incorporates the following elements:

- 24 age/sex cells;
- a payment weight for base-year Medicaid enrollment;
- a payment weight for originally-disabled status (among people of age at least 65);
- a fractional multiplicative adjustment to predicted payments for beneficiaries in working aged status;
- 101 HCC diagnostic categories (88 of the full set of 189 are not used in making payment model predictions);
- increments to payments for 9 diagnostic categories (HCCs) when they occur in beneficiaries whose Medicare entitlement is due to disability (as opposed to age); and
- increments to payments for beneficiaries with 6 combinations of diagnoses, beyond the sum of the incremental payments predicted for each individual diagnosis included in these combinations.

Predictive Accuracy of All Encounter Versus Inpatient Models

Table ES-2 compares the percentage of individual variation in Medicare fee-for-service expenditures predicted by age/sex, PIP-DCG (inpatient), and DCG/HCC (all encounter) risk adjustment models. Adding inpatient diagnoses to demographic predictors (age/sex) increases predictive power six-fold. Adding ambulatory diagnoses and the multi-condition structure of the HCC model further doubles the predictive power.
Table ES-2

Predictive Power of All Encounter (DCG/HCC) Versus Inpatient (PIP-DCG) Models

<table>
<thead>
<tr>
<th>Model</th>
<th>R-Squared&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age/Sex</td>
<td>1.0%</td>
</tr>
<tr>
<td>PIP-DCG</td>
<td>6.2%</td>
</tr>
<tr>
<td>DCG All Encounter (DCG/HCC)</td>
<td>11.2%</td>
</tr>
</tbody>
</table>

<sup>1</sup> Percentage of individual expenditure variation predicted.

NOTE: From Tables 4-1 and 4-2, and Pope, et al. (1999), Table 8-6.

SOURCE: Health Economics Research, Inc.

Table ES-3 compares predictive accuracy of alternative models for beneficiaries with selected prior year inpatient or ambulatory diagnoses. (Predictive ratios close to one indicate accurate prediction, values less than one, underprediction.) The inpatient diagnosis model (PIP-DCG) improves substantially on age/sex, but only when ambulatory diagnoses are incorporated (DCG/HCC) are expenditures for beneficiaries with chronic conditions predicted accurately.

Table ES-4 compares predictive accuracy of alternative models for quantiles of prior year expenditures. Again, the inpatient model (PIP-DCG) improves substantially on age/sex, and the all encounter model (DCG/HCC) improves substantially on the
### Table ES-3

**Predictive Ratios**\(^1\) for All Encounter (DCG/HCC) vs. Inpatient (PIP-DCG) Models: Selected Prior Year Diagnoses

<table>
<thead>
<tr>
<th>Diagnosis(^2)</th>
<th>Age/Sex</th>
<th>PIP-DCG</th>
<th>DCG All Encounter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart failure</td>
<td>0.47</td>
<td>0.74</td>
<td>0.97</td>
</tr>
<tr>
<td>Heart attack</td>
<td>0.45</td>
<td>0.78</td>
<td>0.98</td>
</tr>
<tr>
<td>COPD</td>
<td>0.59</td>
<td>0.79</td>
<td>0.99</td>
</tr>
<tr>
<td>Hip fracture</td>
<td>0.56</td>
<td>0.83</td>
<td>0.99</td>
</tr>
<tr>
<td>Depression</td>
<td>0.54</td>
<td>0.77</td>
<td>0.92</td>
</tr>
<tr>
<td>Colorectal cancer</td>
<td>0.60</td>
<td>0.78</td>
<td>0.98</td>
</tr>
<tr>
<td>Cerebral hemorrhage</td>
<td>0.44</td>
<td>0.73</td>
<td>1.04</td>
</tr>
</tbody>
</table>

\(^1\) Mean predicted cost divided by mean actual cost.

\(^2\) Diagnosis from either inpatient or ambulatory setting.

**NOTE:** From Table 4-8 and Pope et al. (1999), Table 9-1.

**SOURCE:** Health Economics Research, Inc.
Table ES-4

Predictive Ratios\(^1\) for DCG All Encounter (DCG/HCC) vs. Inpatient (PIP-DCG) Models: Prior Year Expenditures

<table>
<thead>
<tr>
<th>Quintiles of Expenditures</th>
<th>Model</th>
<th>Age/Sex</th>
<th>PIP-DCG</th>
<th>DCG All Encounter</th>
</tr>
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<tbody>
<tr>
<td>First</td>
<td>Age/Sex</td>
<td>2.66</td>
<td>2.09</td>
<td>1.23</td>
</tr>
<tr>
<td>Second</td>
<td>Age/Sex</td>
<td>1.93</td>
<td>1.54</td>
<td>1.23</td>
</tr>
<tr>
<td>Third</td>
<td>Age/Sex</td>
<td>1.37</td>
<td>1.10</td>
<td>1.14</td>
</tr>
<tr>
<td>Fourth</td>
<td>Age/Sex</td>
<td>0.95</td>
<td>0.84</td>
<td>1.02</td>
</tr>
<tr>
<td>Fifth</td>
<td>Age/Sex</td>
<td>0.44</td>
<td>0.75</td>
<td>0.86</td>
</tr>
<tr>
<td>Top 5%</td>
<td>Age/Sex</td>
<td>0.28</td>
<td>0.61</td>
<td>0.77</td>
</tr>
<tr>
<td>Top 1%</td>
<td>Age/Sex</td>
<td>0.17</td>
<td>0.47</td>
<td>0.69</td>
</tr>
</tbody>
</table>

\(^1\) Percentage of individual expenditure variation predicted.

**NOTE:** From Table 4-8 and Pope et al. (1999), Table 9-1.

**SOURCE:** Health Economics Research, Inc.
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Inpatient model. Table ES-5 compares predictive accuracy by number of prior year hospitalizations. It is striking that the DCG/HCC model is clearly more accurate than the PIP-DCG model, which is an inpatient-based model.

Comparison of Revised to Previous DCG/HCC Models

Table ES-6 compares the predictive accuracy of the revised DCG/HCC (all encounter) model versus the previous version of the model (Pope et al., 1998). The revised model has more predictive accuracy, but the gains are small. The greatest gain in predictive accuracy is among the most severely ill (those in the top 1% of prior year expenditures). The R-square of the previous model on 1991/1992 data was only 8.83 percent, compared to 10.81 percent on 1996/1997 data (Table ES-6). Thus, the predictive power of diagnosis-based risk adjustment models in newer data is greater, perhaps due to more accurate diagnostic coding over time. Although the gains in predictive accuracy from the revised DCG/HCC classification are small, we believe that the revised system has substantially better clinical face validity and detail.

Conclusions on Research Issues

We investigated 4 major research issues in this project and arrived at the following broad conclusions.

1. Validity of the DCG/HCC model assumption that the predicted expenditures associated with multiple diagnoses are generally modeled accurately as the sum of the incremental expenditures predicted for each individual diagnosis.
### Table ES-5

**Predictive Ratios\(^1\) for All Encounter (DCG/HCC) vs. Inpatient (PIP-DCG) Models: Prior Year Hospitalizations**

<table>
<thead>
<tr>
<th>Hospitalizations</th>
<th>Age/Sex</th>
<th>PIP-DCG</th>
<th>DCG All Encounter</th>
</tr>
</thead>
<tbody>
<tr>
<td>No admissions</td>
<td>1.33</td>
<td>1.07</td>
<td>1.03</td>
</tr>
<tr>
<td>One admission</td>
<td>0.63</td>
<td>1.02</td>
<td>1.02</td>
</tr>
<tr>
<td>Two admissions</td>
<td>0.44</td>
<td>0.91</td>
<td>0.98</td>
</tr>
<tr>
<td>Three or more admissions</td>
<td>0.26</td>
<td>0.69</td>
<td>0.82</td>
</tr>
</tbody>
</table>

\(^1\) Percentage of individual expenditure variation predicted.

**NOTE:** From Table 4-8 and Pope et al. (1999), Table 9-1.

**SOURCE:** Health Economics Research, Inc.
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## Table ES-6

**Predictive Accuracy of Revised All Encounter Model (DCG/HCC) Versus Previous All Encounter Model**

<table>
<thead>
<tr>
<th></th>
<th>Revised²</th>
<th>Previous³</th>
</tr>
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<tbody>
<tr>
<td><strong>R-Squared</strong></td>
<td>11.15%</td>
<td>10.81%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prior Year Expenditure Quintiles</th>
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</thead>
<tbody>
<tr>
<td>First</td>
<td>1.23</td>
<td>1.18</td>
</tr>
<tr>
<td>Second</td>
<td>1.23</td>
<td>1.25</td>
</tr>
<tr>
<td>Third</td>
<td>1.14</td>
<td>1.16</td>
</tr>
<tr>
<td>Fourth</td>
<td>1.02</td>
<td>1.03</td>
</tr>
<tr>
<td>Fifth</td>
<td>0.86</td>
<td>0.85</td>
</tr>
<tr>
<td>Top 5%</td>
<td>0.77</td>
<td>0.76</td>
</tr>
<tr>
<td>Top 1%</td>
<td>0.69</td>
<td>0.66</td>
</tr>
</tbody>
</table>

¹ Both models are estimated on 1996/97 Medicare data.  
² From Tables 4-2 and 4-8.  
³ Computer outputs for R-squared (D9PR11C.OUT); for predictive ratios (D9PR11CC.OUT).

**SOURCE:** Health Economics Research, Inc.
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We examined 35 2- and 3-way non-additive "interactions" among 6 common, high-cost, chronic diseases: diabetes, congestive heart failure, coronary artery disease, cerebrovascular disease, vascular disease, and chronic obstructive pulmonary disease. We also included 3 interactions of several of these conditions with renal failure. When all 38 interactions were included in the model, the percentage of individual expenditure variation predicted rose only from 11.10 percent to 11.13 percent, that is, hardly at all. We conclude that the additivity assumption of the DCG/HCC model is, in general, justified. However, we also found that 6 of the 38 interactions we examined satisfied the criteria of substantial magnitude, statistical significance, and clinical plausibility to be included in the base model. Hence, to improve clinical face validity and predictive accuracy for important subgroups of beneficiaries, we incorporated these 6 diagnosis interactions into our base model.

2. Gain in predictive accuracy from incorporating additional sources of diagnoses, for example, diagnoses from home health agencies.

We investigated using alternative sources of diagnoses to calibrate the DCG/HCC model. Adding diagnoses may improve predictive accuracy, but this gain must be balanced against added data collection costs and questionable clinical validity of diagnoses from some sources. Table ES-7 shows results for percentage of individual expenditure variation explained (R-square). Our base set of diagnoses was all hospital, physician, and clinically-trained nonphysician (e.g., psychologist, podiatrist) diagnoses. Some may question whether radiologist, anesthesiologist, pathologist (RAP) and
### Table ES-7

Predictive Power of DCG/HCC Model Estimated with Alternative Diagnosis Sources

<table>
<thead>
<tr>
<th>Diagnoses Used to Fit Model</th>
<th>R-Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hospital, physician, excluding RAPs and clinically-trained non-physicians</td>
<td>11.03%</td>
</tr>
<tr>
<td>2. Hospital, physician (Base)</td>
<td>11.15%</td>
</tr>
<tr>
<td>3. Model 2 + Home Health Agency</td>
<td>11.65%</td>
</tr>
<tr>
<td>4. Model 3 + SNF, ASC, hospice</td>
<td>11.65%</td>
</tr>
<tr>
<td>5. Model 4 + DME</td>
<td>11.85%</td>
</tr>
<tr>
<td>6. Model 5 + lab, radiology/imaging clinics, misc. (ALL)</td>
<td>11.82%</td>
</tr>
</tbody>
</table>

**NOTE:**
RAPs=Radiologists, Anesthesiologists, Pathologists; SNF=Skilled Nursing Facility; ASC=Ambulatory Surgery Center; DME=Durable Medical Equipment.
From Table 5-4.
Hospital/physician includes clinically trained non-physicians.

**SOURCE:** Health Economics Research, Inc.
Executive Summary

clinically-trained nonphysician diagnoses are as accurate (clinically valid) as other physician diagnoses. Excluding these diagnoses from our base set lowered predictive power slightly. Adding home health agency and durable medical equipment (DME) supplier diagnoses each adds incrementally to predictive power. All other sources of diagnoses either add no predictive power (skilled nursing facility, ambulatory surgery center, hospice) or detract from predictive power (clinical laboratory, radiology/imaging clinics). Adding home health and DME diagnoses also improve the underprediction of expenditures for beneficiaries utilizing home health or DME services in the prior year, although not dramatically (see Table ES-8 and Chapter 5). In addition to predictive accuracy, a complete evaluation of adding or excluding sources of diagnoses must consider the costs of collecting these data from Medicare+Choice plans, as well as the clinical validity of the diagnoses. Detailed consideration of these two issues was beyond the scope of this report.

We also simulated how sensitive payments from our base risk adjustment model are to variations in the diagnoses used to calculate payments. For these simulations, we did not recalibrate the risk adjustment model using alternative sets of diagnoses. Rather we used model parameters estimated with our base set of diagnoses (hospital, physician, and clinically-trained nonphysician), and simulated how health plan payments would change if alternative sets of diagnoses were erroneously included or excluded. Overall, our assessment is that payments are moderately, not severely, affected by changes in the information used. Increases on the order of 1 or 2 percent occur from including home health, nursing facility and ambulatory surgery center diagnoses, while payments would
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increase by 7 percent if all diagnoses – including those from laboratory, DME and nonclinicians – are accepted. A 7 percent overpayment is of concern if plans were to be allowed to include diagnoses appearing on all types of claims, but presumably this type of massive reclassifying would be subject to audit. Ignoring all physician claims has a dramatic effect and disproportionately affects certain chronic diseases, but it would be surprising if this were not true. We take the moderate sensitivity of model predictions to rather broad simulations using different sets of diagnoses as a sign that we have successfully excluded some of the less serious, discretionary, and prevalent diagnoses from our DCG/HCC payment model.

3. Use of durable medical equipment as an additional risk adjustment factor.

Durable medical equipment (DME, e.g., wheelchairs) is potentially attractive as a risk adjuster. It is a Medicare-covered benefit, plausibly identifies beneficiaries who are functionally impaired, may be available in the automated records of Medicare+Choice plans for their entire enrollee populations, does not require expensive and burdensome surveys, and can be accurately calibrated using Medicare fee-for-service data. The major concern about using DME as a risk adjuster is the incentive established for M+C plans to inappropriately supply DME to enrollees to increase Medicare reimbursements.\(^2\) Additional disadvantages are added costs of data collection, not all DME utilization may be captured in Medicare or health plan records (e.g., Medicaid may pay for some DME

\(^2\) Of course, under diagnosis-based risk adjustment plans have incentives to record more diagnoses, which may be even easier than supplying DME.
for dual eligibles), a single base year may be insufficient to capture DME use, variations in use of DME across health plans or FFS/managed care, and difficulty of distinguishing short-term from long-term use of DME.

We investigated how much incorporating DME improved the predictive accuracy of our diagnosis-based DCG/HCC risk adjustment model. We developed 5 DME-based clinical categories (HCCs) and incorporated 6 additional types of DME into existing HCCs. Adding DME to our clinical classification raises predictive power by about 1 percentage point, from 11.15 percent to 12.23 percent. Predictive accuracy for prior year utilizers of DME is substantially improved, and accuracy for prior year home health utilizers is somewhat improved (see Table ES-8 and Chapter 6).

If DME is incorporated into the payment model, utilization of DME would be associated with large incremental payments. For example, we estimate an incremental payment of $7,649 associated with our DME category "Patient Lifts, Power-Operated Wheelchairs, and Hospital Beds". This is virtually the same as the incremental payment associated with a diagnosis of metastatic cancer. The incremental payments triggered by DME utilization would, for some items, be much higher than the cost of supplying the item. Hence, we are concerned about incentives to inappropriately supply DME to enrollees should DME be used as a payment risk adjuster.

4. Evaluation of the predictive accuracy of model variants for additional nonrandom groups of beneficiaries, such as beneficiaries with high home health expenditures.
Executive Summary

An innovation of this project was identifying additional subgroups of Medicare beneficiaries used in evaluating the predictive accuracy of alternative risk adjustment models. Of particular interest are "validation" groups for beneficiaries utilizing home health and DME services, which may proxy for functionally impaired beneficiaries. Table ES-8 presents predictive ratios (mean predicted expenditures divided by mean actual expenditures) for some of the important validation groups we have used in previous projects, and some of the new ones defined for this project. Predictive ratios are presented for 4 risk adjustment models: our base model, a model adding home health diagnoses, a model adding home health and DME diagnoses\(^3\), and a model adding DME utilization as a risk adjuster.

All 4 models predict accurately for beneficiaries classified by most single and multiple diagnoses. The base model underpredicts expenditures for beneficiaries with the highest prior year expenditures. Adding home health and DME diagnoses or DME utilization slightly improves prediction across prior year total expenditure quintiles. But substantial underpredictions remain for beneficiaries with the highest prior year expenditures. The base model underpredicts the total expenditures of beneficiaries with prior year home health or DME expenditures. Adding home health and DME diagnoses, or DME utilization, improves predictive accuracy for beneficiaries with prior year home health utilization moderately. But underprediction for home health utilizers is still present. Adding DME utilization as a risk adjuster substantially improves total

\(^3\) Skilled nursing facility, ambulatory surgery center, and hospice diagnoses are also included in this model, but they have almost no effect on predictive accuracy.
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## Table ES-8

Predictive Accuracy of Alternative Risk Adjustment Models for Medicare Subgroups

<table>
<thead>
<tr>
<th>Validation Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagnoses</strong>^1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANY 1996 CHRONIC CONDITION</td>
<td>0.98</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
</tr>
<tr>
<td>DEPRESSION</td>
<td>0.92</td>
<td>0.95</td>
<td>0.95</td>
<td>0.93</td>
</tr>
<tr>
<td>ALCOHOL / DRUG DEPENDENCE</td>
<td>0.97</td>
<td>0.98</td>
<td>0.98</td>
<td>0.96</td>
</tr>
<tr>
<td>HYPERTENSIVE HEART/RENAL DISEASE</td>
<td>0.95</td>
<td>0.96</td>
<td>0.97</td>
<td>0.96</td>
</tr>
<tr>
<td>BENIGN/UNSPECIFIED HYPERTENSION</td>
<td>0.96</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>DIABETES WITH COMPLICATIONS</td>
<td>0.96</td>
<td>0.97</td>
<td>0.97</td>
<td>0.96</td>
</tr>
<tr>
<td>DIABETES WITHOUT COMPLICATIONS</td>
<td>0.99</td>
<td>1.00</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>HEART FAILURE / CARDIOMYOPATHY</td>
<td>0.97</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
</tr>
<tr>
<td>ACUTE MYOCARDIAL INFARCTION</td>
<td>0.98</td>
<td>1.00</td>
<td>1.00</td>
<td>0.98</td>
</tr>
<tr>
<td>OTHER HEART DISEASE</td>
<td>0.98</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
</tr>
<tr>
<td>CHRONIC OBSTRUCTIVE PULMONARY DISEASE</td>
<td>0.99</td>
<td>0.99</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>COLORECTAL CANCER</td>
<td>0.98</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
</tr>
<tr>
<td>BREAST CANCER</td>
<td>1.08</td>
<td>1.08</td>
<td>1.08</td>
<td>1.08</td>
</tr>
<tr>
<td>LUNG/PANCREAS CANCER</td>
<td>0.90</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>OTHER STROKE</td>
<td>0.96</td>
<td>0.99</td>
<td>1.00</td>
<td>0.97</td>
</tr>
<tr>
<td>INTRACEREBRAL HEMORRHAGE</td>
<td>1.04</td>
<td>1.06</td>
<td>1.06</td>
<td>1.04</td>
</tr>
<tr>
<td>HIP FRACTURE</td>
<td>0.99</td>
<td>1.02</td>
<td>1.04</td>
<td>1.00</td>
</tr>
<tr>
<td>ARTHRITIS</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
<td>0.92</td>
</tr>
<tr>
<td><strong>Multiple Diagnoses</strong>^1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIABETES, CORONARY ARTERY DISEASE</td>
<td>0.98</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
</tr>
<tr>
<td>DIABETES, CEREBROVASCULAR DISEASE</td>
<td>0.98</td>
<td>1.00</td>
<td>1.00</td>
<td>0.98</td>
</tr>
<tr>
<td>HEART FAILURE, COPD</td>
<td>0.98</td>
<td>1.00</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>CORONARY ARTERY DISEASE, VASCULAR DISEASE</td>
<td>0.97</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
</tr>
<tr>
<td>COPD, CORONARY ARTERY DISEASE</td>
<td>0.99</td>
<td>1.00</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>HEART FAILURE, RENAL FAILURE</td>
<td>0.98</td>
<td>1.00</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>DIABETES HEART FAILURE, RENAL FAILURE</td>
<td>0.98</td>
<td>1.00</td>
<td>1.00</td>
<td>0.98</td>
</tr>
<tr>
<td>COPD, CEREBROVASCULAR DISEASE, CORONARY ARTERY DISEASE</td>
<td>0.99</td>
<td>1.00</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>DIABETES, CEREBROVASCULAR DISEASE, VASCULAR DISEASE</td>
<td>0.99</td>
<td>1.01</td>
<td>1.01</td>
<td>0.99</td>
</tr>
<tr>
<td><strong>Expenditures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIRST (LOWEST) QUINTILE, 1996 EXPEND</td>
<td>1.23</td>
<td>1.19</td>
<td>1.17</td>
<td>1.19</td>
</tr>
<tr>
<td>SECOND QUINTILE, 1996 EXPEND</td>
<td>1.23</td>
<td>1.21</td>
<td>1.19</td>
<td>1.19</td>
</tr>
<tr>
<td>MIDDLE QUINTILE, 1996 EXPEND</td>
<td>1.14</td>
<td>1.13</td>
<td>1.12</td>
<td>1.10</td>
</tr>
<tr>
<td>FOURTH QUINTILE, 1996 EXPEND</td>
<td>1.02</td>
<td>1.02</td>
<td>1.02</td>
<td>1.02</td>
</tr>
<tr>
<td>FIFTH (HIGHEST) QUINTILE, 1996 EXPEND</td>
<td>0.86</td>
<td>0.88</td>
<td>0.88</td>
<td>0.89</td>
</tr>
<tr>
<td>Top 5 percent 1996 EXPENDITURES</td>
<td>0.77</td>
<td>0.79</td>
<td>0.80</td>
<td>0.81</td>
</tr>
<tr>
<td>Top 1 percent 1996 EXPENDITURES</td>
<td>0.69</td>
<td>0.70</td>
<td>0.71</td>
<td>0.72</td>
</tr>
</tbody>
</table>

| No home health spending 1996 | 1.10 | 1.08 | 1.08 | 1.07 |
| Home health spending > 0 1996 | 0.75 | 0.79 | 0.80 | 0.82 |
| HHA spending>0:FIRST (LOWEST) QUINTILE, 1996 | 0.99 | 1.03 | 1.03 | 1.02 |
| HHA spending>0:SECOND QUINTILE, 1996 | 0.98 | 1.02 | 1.03 | 1.04 |
| HHA spending>0: MIDDLE QUINTILE, 1996 | 0.88 | 0.93 | 0.93 | 0.96 |
| HHA spending>0:FOURTH QUINTILE, 1996 | 0.75 | 0.80 | 0.81 | 0.84 |
| HHA spending>0:FIFTH (HIGHEST) QUINTILE,1996 | 0.46 | 0.51 | 0.53 | 0.55 |
| HHA spending>0: top 10% of HHA spending 1996 | 0.39 | 0.43 | 0.45 | 0.47 |
| HHA spending>0: top 5% of HHA spending 1996 | 0.33 | 0.37 | 0.39 | 0.40 |
| No DME spending 1996 | 1.09 | 1.08 | 1.06 | 1.02 |
| DME spending > 0 1996 | 0.82 | 0.84 | 0.87 | 0.96 |
| DME spending>0:FIRST (LOWEST) QUINTILE, 1996 | 0.94 | 0.95 | 0.97 | 0.96 |
| DME spending>0:SECOND QUINTILE, 1996 | 0.89 | 0.91 | 0.93 | 1.00 |
| DME spending>0:MIDDLE QUINTILE, 1996 | 0.89 | 0.91 | 0.94 | 1.00 |
| DME spending>0:FOURTH QUINTILE, 1996 | 0.82 | 0.84 | 0.88 | 0.97 |
| DME spending>0:FIFTH (HIGHEST) QUINTILE,1996 | 0.65 | 0.68 | 0.72 | 0.91 |
| DME spending>0: top 10% of DME spending 1996 | 0.59 | 0.61 | 0.66 | 0.87 |
| DME spending>0: top 5% of DME spending 1996 | 0.57 | 0.59 | 0.64 | 0.81 |

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Health Economics Research, Inc.  
DCG/HCC Models for Medicare Risk Adjustment: ES-17
## Executive Summary

Table ES-8 (continued)

Predictive Accuracy of Alternative Risk Adjustment Models for Medicare Subgroups

<table>
<thead>
<tr>
<th>Validation Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DME</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>oxygen supplies/equipment (DME)</td>
<td>0.65</td>
<td>0.67</td>
<td>0.70</td>
<td>0.99</td>
</tr>
<tr>
<td>wheelchairs (DME)</td>
<td>0.68</td>
<td>0.71</td>
<td>0.77</td>
<td>0.95</td>
</tr>
<tr>
<td>walkers (DME)</td>
<td>0.84</td>
<td>0.86</td>
<td>0.88</td>
<td>1.03</td>
</tr>
<tr>
<td><strong>HOSPITAL ADMISSIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 1996 HOSP ADMISSIONS</td>
<td>1.03</td>
<td>1.02</td>
<td>1.02</td>
<td>1.02</td>
</tr>
<tr>
<td>1 1996 HOSP ADMISSIONS</td>
<td>1.02</td>
<td>1.03</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>2 1996 HOSP ADMISSIONS</td>
<td>0.98</td>
<td>0.99</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>3+ 1996 HOSP ADMISSIONS</td>
<td>0.82</td>
<td>0.83</td>
<td>0.83</td>
<td>0.84</td>
</tr>
</tbody>
</table>

**NOTES:**

1 Calibrated using hospital, physician, and clinically-trained nonphysician diagnoses (Source=1-5).
2 Home health agency (HHA) diagnoses added to base model (Source=1-5, 6b).
3 HHA and durable medical equipment (DME) diagnoses added to base model (Source=1-6, 8a).
4 Utilization of DME added to the base model.
5 Validation group diagnoses assigned using Source=1-6.

**OUTPUT:** From Table 5-5 and Table 6-9.

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
Executive Summary

Expenditure prediction for DME utilizers so that prediction is quite accurate, except for the highest prior year DME utilizers. But adding only home health or DME diagnoses improves total expenditure prediction for DME utilizers only slightly (home health diagnoses) to moderately (DME diagnoses). The base model underpredicts for beneficiaries with 3 or more prior year hospitalizations; adding home health and DME diagnoses, or DME utilization improves accuracy only slightly for this group.

Concluding Remark

Updates and refinements to the DxGroups, the Condition Categories, and the hierarchical rules for HCCs have improved clinical face validity. Also, inclusion of diagnosis interactions, home health and durable medical equipment diagnoses, and durable medical equipment utilization will add to predictive accuracy. However, the largest increase in predictive accuracy (resulting in our base prospective payment model having an R-square of over 11 percent) found in this project is associated with our use of newer (1996-1997) Medicare data.
1

Introduction and Overview

The Health Care Financing Administration (HCFA) implemented inpatient encounter-based risk adjustment for a portion of capitation payments to Medicare + Choice (M+C) plans beginning January 1, 2000. The risk adjustment method used is the Principal Inpatient Diagnostic Cost Group or PIP-DCG model (Pope et al., 1999).

Medicare is scheduled to transition to all-encounter-based risk adjustment in 2004. The all-encounter model will add information from hospital outpatient and physician encounters to information from inpatient encounter records. The all-encounter risk adjustment model within the Diagnostic Cost Group, or DCG, family of risk adjustment models is known as the Diagnostic Cost Group, Hierarchical Condition Category model, or DCG/HCC model. This report describes the latest refinements and updates to the DCG/HCC model resulting from research funded by the Health Care Financing Administration.

Table 1-1 shows the multidisciplinary team that developed the latest version of the Medicare DCG/HCC model. This is the same team that developed Medicare's PIP-DCG model. Health Economics Research, Inc. (HER), based in Waltham, Massachusetts, was the prime contractor with HCFA for Medicare model development. Gregory Pope was the Project Director for HER. Arlene Ash, Ph.D. and Randall Ellis, Ph.D. of Boston University, the originators of the DCG family of risk adjustment models, served as consultants and active participants in the model refinement. Primary clinical
Table 1-1

DCG All Encounter Medicare Model Development Team

Health Economics Research, Inc.
Gregory Pope, Project Director

Harvard Medical School Clinical Consultants
John Ayanian, M.D., M.P.P.
David Bates, M.D., M.Sc.
Helen Burstin, M.D., M.P.H.
Lisa Iezzoni, M.D., M.Sc.
Ed Marcantonio, M.D., S.M.

Boston University Consultants
Arlene Ash, Ph.D.
Randall Ellis, Ph.D.

Additional Clinical Consultants

input was provided by a panel of physicians affiliated with Harvard Medical School in Boston. Additional clinical input was obtained from several physician specialists.

The current DCG/HCC model as presented in this report builds on earlier research sponsored by HCFA. All-encounter DCG models were first developed in the early-mid 1990s for Medicare. This first iteration of the models is reported in Ellis et al. (1996). Many of the principles for later model development were developed as part of this initial effort. HCFA then funded parallel projects to extend the DCG/HCC framework to
commercial and Medicaid populations (Ash et al., 1998), and to refine and update the Medicare DCG/HCC model (Pope et al., 1998). The current project thus represents a second update and refinement of the Medicare DCG/HCC models.

The current project reflects a combination of updates, refinements, and new research involving the DCG/HCC models. The major updates to the DCG/HCC models were:

- recalibration of the model using 1996/1997 data (as compared to the 1991/92 data used in our previous projects);
- updating ICD-9-CM diagnosis codes to be current through FY 2000.

The major refinements to the model were:

- more clinically detailed diagnostic classification system;
- adjustments for the joint effect on expenditures of certain combinations of diagnoses;
- more detailed adjustment for expenditure differences of beneficiaries entitled to Medicare by disability;
- calibration of Medicaid, originally disabled, and working aged demographic factors in conjunction with the updated DCG/HCC model.

The major research issues we investigated were:

- validity of the DCG/HCC model assumption that the predicted expenditures associated with multiple diagnoses are generally modeled accurately as the sum of the incremental expenditures predicted for each (individual) diagnosis.
- gain in predictive accuracy from incorporating additional sources of diagnoses, for example, diagnoses from home health agencies.
- use of durable medical equipment as an additional risk adjustment factor.
• evaluation of the predictive accuracy of model variants for additional nonrandom groups of beneficiaries, such as beneficiaries with high home health expenditures.

The remainder of the report is organized as follows. Chapter 2 discusses file construction with the 1996/97 Medicare fee-for-service 5 percent sample data used for this report. Chapter 3 describes the updated DCG/HCC diagnostic classification system. Chapter 4 details the development and evaluation of alternative diagnosis-based prospective risk adjustment models. The effects of adjustments for the joint effects of combinations of diagnoses (“diagnosis interactions”) and differences for the under-age-65 disabled are examined. Also, the base version of the model is calibrated with age-specific adjustments for Medicaid enrollment and original entitlement by disability, and with a multiplicative adjustment for working-aged status. Chapter 5 presents our analysis of model sensitivity to use of different sources of diagnosis, including gains in predictive accuracy from use of additional sources. Chapter 6 contains our analysis of durable medical equipment as an additional risk adjuster, including a DCG/HCC model variant that incorporates DME. We also briefly consider the use of selected medical procedures, such as organ transplants, for risk adjustment. Chapters 4-6 consider only prospective risk adjustment models. In Chapter 7 we present our revised concurrent DCG/HCC risk adjustment model.
File Construction


In this chapter, we first describe sample selection. Then we discuss creation of our Medicare payment variables. Finally, we discuss data used for risk adjustment.
2.1 Sample Selection

Our "master" sample is the union of Medicare beneficiaries appearing on either the 1996 or 1997 Medicare "denominator" (enrollment) files. Prospective and concurrent analytic samples were extracted from this master sample. We first describe our prospective sample, then our concurrent sample.

2.1.1 Prospective Sample

Our prospective sample includes beneficiaries who satisfy the following conditions:

1. Continuously enrolled in both Parts A and B of Medicare from 1/1/96;
2. at least one month in 1997 entitled by age or disability, not residing in a hospice, and not enrolled in an HMO;
3. no months of HMO enrollment in 1996;
4. US residence throughout 1996 and 1997; and
5. no months of working aged status in either 1996 or 1997.

The primary goal of these conditions is to ensure that we analyze beneficiaries with a complete set of claims in 1996 to create a comprehensive diagnostic profile, and a complete set of claims in 1997 to measure total expenditures accurately. The first condition is necessary to have a complete set of inpatient and outpatient claims for all sample beneficiaries in 1996 and 1997.

The second condition excludes beneficiaries who are only ESRD-eligible, only hospice-residing, or only HMO-enrolled in 1997. HMO months are excluded because...
Medicare does not collect a full set of encounter claims for months beneficiaries are enrolled in HMOs. Hospice months are excluded because HMOs are not responsible for hospice care. ESRD months are excluded because ESRD eligibles have not been allowed to enroll in Medicare HMOs. In a change from our earlier file constructions with 1991/1992 and 1995/1996 data (Ellis et al., 1996; Pope et al., 1999), we now include beneficiaries who have a mixture of FFS/HMO, or ESRD/aged-disabled months in the prediction year (1997). Previously we excluded entirely beneficiaries with any HMO or ESRD months in either the base or prediction years.

The third condition excludes beneficiaries with any base year (1996) months enrolled in a Medicare HMO. No claims are available for these months, hence the base year diagnostic profile may be incomplete. The fourth condition eliminates beneficiaries residing (and possibly receiving their medical care) outside the United States. The fifth condition eliminates beneficiaries for whom a private group health insurance plan was the primary payer to Medicare (known as "working aged" status) at any time in 1996 or 1997. Medicare may not have a complete set of claims for working aged beneficiaries.

Table 2-1 shows the number of beneficiaries excluded by the various sample restrictions. Beneficiaries may be excluded for more than one reason. The Medicare 5 percent standard analytic sample contains a total of 2,017,964 beneficiaries with any eligibility in 1997. Of these, 1,394,701 beneficiaries, or 69 percent, constitute our prospective sample. The largest sample exclusions are due to not being continuously enrolled in Medicare Parts A and B from the beginning of 1996 (presumably mostly newly-eligible beneficiaries) and being HMO-enrolled in either 1996 or 1997.
2.1.2 Concurrent Sample

Our concurrent sample was defined to include beneficiaries who satisfy the following conditions:

1. Eligible for both Medicare Part A and Part B for any months of Medicare eligibility in 1997;
2. at least one month in 1997 entitled by age or disability, not residing in a hospice, and not enrolled in an HMO;
3. US residence in 1997; and
4. no months of working aged status in 1997.

The first condition is necessary for a complete set of inpatient and outpatient claims during 1997. Note that beneficiaries need not be Part A and B eligible from the beginning of 1997 to be included in the concurrent sample. They may become Medicare-eligible during 1997 and qualify for the concurrent sample. The second condition excludes beneficiaries with only ESRD-eligible, only hospice-residing, or only HMO-enrolled months in 1997. The third condition excludes non-US residents, and the fourth condition excludes beneficiaries with any working aged months in 1997.

Of the 2,017,964 beneficiaries in the 5 percent sample with any 1997 eligibility, 1,581,370, or 78 percent, qualified for our concurrent sample.

2.2 1997 Medicare Expenditures

Medicare payments were summed from the Medpar inpatient file (including SNF) and four 1997 Standard Analytic Files: hospital outpatient, Part B physician/supplier, home health, and Durable Medical Equipment (DME). The paid amount recorded on
each SAF claim was included in total Medicare payments. For the Medpar file, we used the following definition of payments:

\[ \text{Payments} = \text{Medpar Medicare Payment Amount} \times 52 + \text{Medpar Total Pass Through Amount} \times 47 - \text{Medpar Indirect Medical Education (IME) Amount} \times 45. \]

Thus, our payment variable includes all Medicare payments exclusive of:

- deductibles and copayments paid by beneficiaries;
- hospice payments; and
- indirect medical education (IME) payments.

We exclude hospice and IME payments because these are not paid to HMOs (see Pope et al., 1999 for further discussion).

Payments were summed only for 1997 months that beneficiaries were enrolled in fee-for-service, not enrolled in hospice, and entitled by age or disability. Months enrolled in an HMO, hospice, or ESRD are excluded. After payments were summed, they were annualized by dividing them by the fraction of months in 1997 each beneficiary was Medicare-eligible by age or disability, enrolled in FFS, and not enrolled in hospice. All analyses are then weighted by this same fraction. Annualization and weighting ensures that monthly payments are correctly estimated for all beneficiaries, including people who died (Ellis et al., 1996).

Table 2-2 shows the distribution of annualized 1997 payments for the prospective sample. Mean payments are $5,314, with a standard error of $12. The maximum payment is $1,997,706, and about 10 percent of the sample are nonusers (zero payments).
Table 2-3 compares frequencies and mean payments between the 1995/1996 (Pope et al., 1999) and 1996/1997 prospective samples. Beneficiaries entitled by disability comprise a slightly higher percentage of the 1996/1997 sample (11.7% versus 11.2%), with most of the gain occurring in the older disabled. The older elderly (age 85+) and Medicaid dual eligibles also comprise slightly higher proportions of the 1996/1997 sample. Ratios of mean subgroup payments to overall mean payments are fairly stable across samples.

Table 2-4 shows descriptive statistics of components of 1997 total annualized payments. Inpatient payments comprise 48 percent of the total, and Part B excluding laboratory 22 percent. Less than 5 percent of the sample have any SNF expenditures, less than 12 percent any home health expenditures, less than 18 percent any DME expenditures, and less than 22 percent any inpatient expenditures.

### 2.3 Information Used for Risk Adjustment

Our risk adjustment models primarily use demographics and diagnoses to predict expenditures. The demographic factors we employ are age, sex, originally disabled status, and Medicaid status. We defined age and sex factors identically to Pope et al. (1999) as 24 age/sex cells using prorated months when a beneficiary spent 1997 in more than one age range. Ever disabled is also defined identically to the previous project. Following HCFA practice, we have now relabelled "ever disabled" to "originally disabled". By either name, beneficiaries in this status were originally entitled to Medicare by disability, but are currently (1997) entitled by age. For prospective
analyses, a person is defined to be in Medicaid status if he or she had any months of Medicaid eligibility in 1996. For concurrent analyses, Medicaid status is defined as any Medicaid eligibility in 1997.

In prospective modelling, diagnoses from 1996 claims are used to predict 1997 expenditures. In concurrent modelling, 1997 diagnoses are used to explain 1997 expenditures. Diagnoses from Medicare claims were assigned to one of the following Sources:

1. hospital inpatient—principal diagnoses
2. hospital inpatient—secondary diagnoses
3. hospital outpatient department
4. physician
   4a. physicians, excluding RAPs
   4b. radiologist, anesthesiologist, pathologist (RAPs)
5. clinically-trained nonphysician (e.g., psychologist, therapist, podiatrist)
6. facility types
   6a. ambulatory surgery center
   6b. home health agency
   6c. skilled nursing facility
   6d. hospice
7. diagnostic testing
   7a. non-laboratory, e.g., radiology imaging clinics
   7b. clinical laboratory
8. durable medical equipment/medical supplies
   8a. DME diagnosis from DME Standard Analytic File
   8b. DME diagnosis from Part B file
9. other/miscellaneous
We conduct an analysis of sensitivity of the prospective risk adjustment model to source of diagnoses in Chapter 5. But for most of our analyses, we use Sources 1-5 to provide diagnoses for risk adjustment.

Diagnoses from both header and line items were included from Medicare Part B records (claims). For Part B line item diagnoses, we assigned the Source based on the HCFA provider specialty code. The Source of header diagnoses was assigned based on the lowest-numbered Source of any of the line items on that claim.

For some prospective risk adjustment model variants we used DME and procedure utilization as additional risk adjusters. These predictors are discussed in Chapter 6.
Table 2-1
Exclusions to Create 1996/97 Prospective Modeling Sample

<table>
<thead>
<tr>
<th>Exclusions to Create 1996/97 Prospective Modeling Sample</th>
<th>Beneficiaries</th>
<th>Percentage</th>
<th>Months</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligible in 1997, Total ¹</td>
<td>2,017,964</td>
<td>100.0%</td>
<td>23,074,601</td>
<td>100.0%</td>
</tr>
<tr>
<td>Prospective Modeling Sample Exclusions ²</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not continuously Medicare A/B enrolled from 1/1/96 ³</td>
<td>349,443</td>
<td>17.3</td>
<td>3,537,349</td>
<td>15.3</td>
</tr>
<tr>
<td>HMO-enrolled in 1996 ⁴</td>
<td>244,473</td>
<td>12.1</td>
<td>2,877,620</td>
<td>12.5</td>
</tr>
<tr>
<td>No months non-HMO, non-hospice aged/disabled eligibility, 1997</td>
<td>260,026</td>
<td>12.9</td>
<td>2,981,702</td>
<td>12.9</td>
</tr>
<tr>
<td>only HMO months</td>
<td>245,019</td>
<td>12.1</td>
<td>2,842,019</td>
<td>12.3</td>
</tr>
<tr>
<td>only ESRD months</td>
<td>11,264</td>
<td>0.6</td>
<td>116,832</td>
<td>0.5</td>
</tr>
<tr>
<td>only hospice months</td>
<td>2,107</td>
<td>0.1</td>
<td>8,797</td>
<td>0.0</td>
</tr>
<tr>
<td>mix of HMO/ESRD/hospice months</td>
<td>1,636</td>
<td>0.1</td>
<td>14,054</td>
<td>0.1</td>
</tr>
<tr>
<td>Any working aged months, 1996 or 1997</td>
<td>65,474</td>
<td>3.2</td>
<td>744,646</td>
<td>3.2</td>
</tr>
<tr>
<td>Any months of non-US residence, 1996 or 1997</td>
<td>16,772</td>
<td>0.8</td>
<td>193,319</td>
<td>0.8</td>
</tr>
<tr>
<td>Prospective Sample</td>
<td>1,394,701</td>
<td>69.1</td>
<td>16,335,299</td>
<td>70.8</td>
</tr>
</tbody>
</table>

NOTES:
¹Eligible Part A or Part B Medicare at least one month in 1997. Five percent sample of Medicare beneficiaries.
²A person may be excluded for more than one reason. Hence, sum of number of people excluded for each reason is greater than the difference between 1997 eligibles and the prospective modeling sample.
³Until 12/31/97 or date of death.
⁴Enrolled in an HMO at least one month in 1996.

Computer output: DENOM02D.OUT

SOURCE: Health Economics Research, Inc. analysis of 1996/97 Medicare 5% sample data.
<table>
<thead>
<tr>
<th>N</th>
<th>1,394,701</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>$5,314</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$13,822</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>260%</td>
</tr>
<tr>
<td>Standard Error</td>
<td>$12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Max</th>
<th>$1,997,706</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>78,748</td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>31,437</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>17,142</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>4,114</td>
<td></td>
</tr>
<tr>
<td>50 (Median)</td>
<td>844</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>189</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

% non-users (zero payments) | 9.7%

---

1 For prospective modelling sample.
2 Weighted by fraction of year alive.
3 The maximums shown is of annualized expenditures. The maximum of actual expenditures was $566,302.

Output: D9P001A.OU2

### Table 2-3

**Frequencies and Mean Annualized Payments for Medicare Subgroups: 1995/1996 and 1996/1997 Prospective Modeling Samples**

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>1995/1996 Sample(^1)</th>
<th>1996/1997 Sample(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Percent of Total Sample</td>
</tr>
<tr>
<td>Overall Sample</td>
<td>1,387,105</td>
<td>100.0%</td>
</tr>
<tr>
<td>Disabled (age &lt;= 64)</td>
<td>154,784</td>
<td>11.2</td>
</tr>
<tr>
<td>Younger disabled (age &lt;= 44)</td>
<td>55,579</td>
<td>4.0</td>
</tr>
<tr>
<td>Older disabled (age 45 - 64)</td>
<td>99,205</td>
<td>7.2</td>
</tr>
<tr>
<td>Aged (age &gt;= 65)</td>
<td>1,232,321</td>
<td>88.8</td>
</tr>
<tr>
<td>Ever disabled</td>
<td>87,154</td>
<td>6.3</td>
</tr>
<tr>
<td>Younger elderly (age 65 - 84)</td>
<td>1,073,853</td>
<td>77.4</td>
</tr>
<tr>
<td>Older Elderly (age 85+)</td>
<td>158,468</td>
<td>11.4</td>
</tr>
<tr>
<td>Medicaid(^4)</td>
<td>204,267</td>
<td>14.7</td>
</tr>
<tr>
<td>Disabled (age &lt;= 64)</td>
<td>66,370</td>
<td>4.8</td>
</tr>
<tr>
<td>Elderly (age &gt;= 65)</td>
<td>137,897</td>
<td>9.9</td>
</tr>
<tr>
<td>Non-Medicaid</td>
<td>1,182,838</td>
<td>85.3</td>
</tr>
<tr>
<td>Disabled (age &lt;= 64)</td>
<td>88,414</td>
<td>6.4</td>
</tr>
<tr>
<td>Elderly (age &gt;= 65)</td>
<td>1,094,424</td>
<td>78.9</td>
</tr>
<tr>
<td>Female</td>
<td>812,354</td>
<td>58.6</td>
</tr>
<tr>
<td>Male</td>
<td>574,760</td>
<td>41.4</td>
</tr>
</tbody>
</table>

**NOTES:**

1 Excludes part-year HMO and ESRD enrollees (see text).
2 Excluding IME and Hospice payments. Payments are annualized and weighted by fraction of year eligible.
3 Includes part-year HMO and ESRD enrollees (see text).
4 Medicaid status is defined using the Medicaid buy-in indicator from the denominator files.

**OUTPUTS:** D9P002A.srt

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare claims data.
### Table 2-4

Statistics on Components of 1997 Medicare Payments for Prospective Sample

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Error of Mean</th>
<th>% of Total $</th>
<th>% Zero</th>
<th>Maximum²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>1,394,701</td>
<td>$5,314</td>
<td>$11.95</td>
<td>100.0%</td>
<td>9.7%</td>
<td>$1,997,706</td>
</tr>
<tr>
<td><strong>Inpatient</strong></td>
<td>1,394,701</td>
<td>2,535</td>
<td>8.52</td>
<td>47.7%</td>
<td>78.5%</td>
<td>1,963,008</td>
</tr>
<tr>
<td><strong>Hospital Outpatient</strong></td>
<td>1,394,701</td>
<td>439</td>
<td>1.12</td>
<td>8.3%</td>
<td>37.3%</td>
<td>128,764</td>
</tr>
<tr>
<td><strong>Part B, Excluding Laboratory</strong></td>
<td>1,394,701</td>
<td>1,178</td>
<td>1.95</td>
<td>22.2%</td>
<td>13.0%</td>
<td>447,874</td>
</tr>
<tr>
<td><strong>Laboratory</strong></td>
<td>1,394,701</td>
<td>75</td>
<td>0.12</td>
<td>1.4%</td>
<td>35.8%</td>
<td>10,359</td>
</tr>
<tr>
<td><strong>Skilled Nursing Facility</strong></td>
<td>1,394,701</td>
<td>372</td>
<td>2.08</td>
<td>7.0%</td>
<td>95.4%</td>
<td>195,192</td>
</tr>
<tr>
<td><strong>Home Health</strong></td>
<td>1,394,701</td>
<td>564</td>
<td>2.64</td>
<td>10.6%</td>
<td>88.6%</td>
<td>138,022</td>
</tr>
<tr>
<td><strong>Durable Medical Equipment</strong></td>
<td>1,394,701</td>
<td>150</td>
<td>0.64</td>
<td>2.8%</td>
<td>82.1%</td>
<td>164,192</td>
</tr>
</tbody>
</table>

¹Excludes Indirect Medical Education payments.
²The maximums shown are of annualized expenditures. The maximum of actual total expenditures was $566,302.

**NOTES:**
All payments are annualized.
No hospice payments are included because hospice payments were excluded from our expenditure variable.

**OUTPUT:** D9P001B.OUT

**SOURCE:** Health Economics Research, Inc. analysis of 1996/97 Medicare 5% sample data.
The diagnostic classification developed for this project builds on the classification originally developed by Ellis et al. (1996) and refined by Pope et al. (1998). Further extensive revisions in the diagnostic classification were completed for this project. We begin by reviewing the principles we have established for our classification system. We then give an overview of the system and the current round of revisions, and examples from the revised classification.

### 3.1 Principles

Ten principles guide the design of the Diagnostic Cost Groups/Hierarchical Condition Categories (DCG/HCC) diagnostic classification system and models.

1. **Diagnostic categories should be clinically meaningful.**

   Each diagnostic category is a grouping of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes. These codes should all relate to a reasonably well-specified medical condition, symptom, or finding which defines the category.

   Clinical meaningfulness improves the face validity of the classification system to clinicians, improves its interpretability, facilitates development of the clinical logic of
models based on it, and increases its usefulness for disease management and quality monitoring.

2. **Diagnostic categories should predict medical expenditures.**

   A primary purpose is to develop a system for risk-adjusting capitation payments to Medicare + Choice plans. Therefore, the clinical classification should be useful in predicting expenditures. ICD-9-CM codes should be grouped into categories that are reasonably homogeneous with respect to their effect on both future (prospective risk adjustment) and current (concurrent risk adjustment) costs. Diagnoses with high cost implications should be distinguished from low-cost ones.

3. **Diagnostic categories that will affect payments should have adequate sample sizes to permit accurate and stable estimates of expenditures.**

   Medical problems that are observed in only a few hundred people out of more than a million are too rare to be able to obtain stable and replicable estimates of their effects on costs. Diagnostic categories used in establishing payments should have adequate sample sizes in available data sets. Given the extreme skewness and large outliers that characterize medical expenditure distributions, diagnostic categories with small sample sizes are likely to be mis-priced.
4. In creating an individual’s clinical profile, hierarchies should be used to characterize the person’s illness level within each disease process, while the effects of unrelated disease processes should be cumulative.

Because each new medical problem adds to an individual’s total disease burden, unrelated disease processes should contribute cumulatively to predicted costs of care. However, the most severe manifestation of a given disease process principally defines its impact on costs. Therefore, related conditions should be treated hierarchically, with more severe manifestations of a condition dominating less serious ones. In particular, a new code that adds a low-level, related medical problem to a sick person’s profile will not increase that person’s predicted cost.

5. The diagnostic classification should encourage specific coding.

Vague diagnostic codes should be grouped with less severe and lower-paying diagnostic categories to provide incentives for more specific diagnostic coding.

6. The diagnostic classification should not reward coding proliferation.

The classification should not measure greater disease burden simply because more ICD-9-CM codes are present. Hence, neither the number of times that a particular code appears, nor the presence of additional, closely-related codes that all indicate the same condition should increase predicted costs (see Principle 4).
7. **Providers should not be penalized for recording additional diagnoses.**

   This principle has two consequences for modeling: 1) no condition category should carry a negative payment weight, and 2) a condition that is higher-ranked in a disease hierarchy should have at least as large a payment weight as a lower-ranked condition in the same hierarchy.

8. **The classification system should be internally consistent (transitive).**

   If diagnostic category A is higher-ranked than category B in a disease hierarchy, and category B is higher-ranked than category C, then category A should be higher-ranked than category C. Transitivity improves the internal consistency of the classification system, and ensures that the assignment of diagnostic categories will be independent of the order in which hierarchical exclusion rules are applied.

9. **The diagnostic classification should assign all ICD-9-CM codes.**

   Since each diagnostic code potentially contains relevant clinical information, the classification should categorize all ICD-9-CM codes.

10. **Discretionary diagnostic categories should be excluded from prospective payment models.**

    Diagnoses that are particularly subject to intentional or unintentional discretionary coding variation or inappropriate coding by health plans/providers, or that are not clinically or empirically credible predictors of future expenditures, should not increase cost predictions. We excluded diagnoses from prospective payment models because they
were vague/nonspecific (e.g., symptoms), discretionary in medical treatment or coding (e.g., osteoarthritis), not medically significant (e.g., sprains/strains), transitory or admitting of definitive treatment this year (e.g., appendicitis). Also, we excluded diagnoses that did not, empirically, add to future costs. Excluding these diagnoses reduces the sensitivity of the payment models to coding variation, coding proliferation (Cf. Principle 6, above), "gaming", and "upcoding". See Pope et al. (1998), Chapter 2, for further discussion of diagnostic exclusions.

Several of these principles were followed absolutely, but most involved tradeoffs requiring judgment. Principles 7 (monotonicity), 8 (transitivity), and 9 (exhaustive classification of ICD-9-CM codes that are valid in the year 2000, including "V" and "E" codes) were always satisfied. As will be discussed further in Chapter 4, if the expenditure weights for our models did not originally satisfy monotonicity, we imposed constraints to create models that did. Similarly, we ensured that all of the diagnostic hierarchies in our classification satisfy the principle of transitivity.

Judgment was used to make tradeoffs among the other principles. For example, clinical meaningfulness (Principle 1) is often best served by creating a very large number of very detailed clinical groupings. But a large number of groupings conflict with adequate sample sizes for each category (Principle 3). Another tradeoff is encouraging specific coding (Principle 5) versus predictive power (Principle 2). In current coding practice, nonspecific codes are used very frequently. But if these codes are excluded
from or downweighted in the classification system, substantial predictive power would be
sacrificed. Excluding discretionary codes (Principle 10) can also conflict with Principle 2
(predictive power). Excluding diagnoses from the model generally reduces predictive
power.

We approached the inherent tradeoffs involved in designing a classification
system using empirical evidence, clinical judgment, and experience in designing payment
systems. The 1996/1997 Medicare fee-for-service 5 percent sample analytic datafile as
described in Chapter 2 was used to provide empirical evidence on frequencies of
diagnoses, mean and incremental expenditures, and predictive power/fit of the risk
adjustment models. Our panel of clinical consultants (see Table 1-1) determined clinical
meaningfulness (Principle 1), relationships among disease processes (Principle 4), and
discretionary diagnoses (Principle 10), as well as providing general input on the clinical
groupings. The Project Director and Boston University consultants (see Table 1-1) have
considerable experience in designing medical provider payment systems, and provided
input on incentives established by the classification system and likely provider responses
to it. The DCG/HCC clinical classification system has been designed to achieve a good
balance among competing goals for a real-world health-based payment system.

1 In several cases, we allowed monotonicity to be violated for specific clinical reasons. These included completed
versus uncompleted pregnancies, and kidney transplants versus dialysis status.
3.2 Elements and Organization

The DCG/HCC diagnostic classification system begins by classifying each of the more than 15,000 ICD-9-CM diagnosis codes, as shown in Table 3-1. These are first grouped into 804 diagnostic groupings, or "DxGroups". Each ICD-9-CM code maps into exactly one DxGroup, which represents a specific medical condition. Examples are DxGroup “3.02 non-viral encephalitis, meningoencephalitis, other CNS infection” “28.01 acute liver disease, including acute liver necrosis/failure, abscess, infarction,” and “30.01 gallstones with gallbladder inflammation and other gallbladder disease.” The DxGroups are each given an integer part, and a two decimal extension, with closely-related DxGroups sharing the same integer part. The integer part relates to the next highest level of aggregation, to be explained below. Each DxGroup also has a descriptive label naming the most common or clinically-important specific diagnoses included in the group.

DxGroups are further aggregated into 189 "Condition Categories", or CCs. These CCs describe major diseases and are broadly organized into body systems, somewhat analogous to the ICD-9-CM major diagnostic categories. The ICD-9-CM diagnoses that define a single CC are not as similar as the ICD-9-CM codes in a single DxGroup. However, the CCs are designed to be both clinically- and cost-similar, reflecting the principles just described. The integer assigned to each CC corresponds to the integer part of the DxGroups that constitute it.

Hierarchies are imposed among related CCs according to Principle 4 discussed in the preceding section. After the hierarchies are imposed, the CCs become "Hierarchical
Condition Categories”, or HCCs. HCCs are clinically meaningful categories, although at a more aggregate level than the DxGroups. Examples of HCCs are HCC 3 “Central Nervous System Infection”, HCC 28 “Acute Liver Failure/Disease” and HCC 30 “Gallbladder and Biliary Tract Disorders.” Note that these three HCCs correspond to the three DxGroups (3.02, 28.01 and 30.01) discussed two paragraphs previous. The HCCs, together with demographic information, are used to predict next year's (prospective risk adjustment) or this year's (concurrent risk adjustment) expenditures.

At the level of the person, neither DxGroups nor HCCs are mutually exclusive. A beneficiary may be assigned to none, one, or more than one DxGroup or HCC. An individual’s HCCs, taken as a group, yield a comprehensive clinical profile. For example, a man with heart disease, cerebrovascular disease, and cancer will be assigned to three separate HCCs, and his predicted cost will reflect increments for each of these problems.

The kind of cumulative model structure that we use is parsimonious, flexible, and comprehensive. As opposed to a clinical algorithm that assigns persons to mutually exclusive clinical categories, an additive model can “price” the effects of tens of thousands of distinct clinical profiles using fewer than 200 parameters. The DCG/HCC models impose fewer a priori constraints on the allowed combinations of diagnoses than a mutually exclusive grouping, giving it greater flexibility to represent patterns of coexisting conditions. Similarly, because the DCG/HCC model recognizes all combinations of diagnoses, it provides a comprehensive clinical profile of each
individual, something not possible with mutually exclusive groupings that are necessarily limited in number.

We describe our models as cumulative rather than additive, to reflect the possibility that for some diseases costs may go up more quickly, or less quickly than the separate cost of each disease. For example, the cost of a person with both diabetes and congestive heart failure (CHF) could be greater or less than the sum of the separate costs for people who have only diabetes or only CHF. Whether a relationship is additive, more-than-additive, or less-than-additive is empirically testable. In Chapter 4, we conduct empirical tests of the additivity hypothesis in our Medicare fee-for-service data. We postpone a detailed discussion of our methods and results until Chapter 4. However, the bottom line is that simple additivity generally provides a very good fit to these data. In a few important cases, additivity is not supported, and we modify our model accordingly.

Severity of illness is captured in the DCG/HCC models in two ways. Within a particular type of illness or body system, disease hierarchies assign a person to the most severe manifestation, for example, metastatic cancer rather than prostate cancer. In addition, the burden of comorbid or coexisting conditions is captured through the accumulation of disease burden across multiple body systems or disease types. So if a person with metastatic cancer also suffers from congestive heart failure, the two disease impacts are both used in predicting the total disease burden.

In previous projects, each DxGroup was assigned to one and only one HCC. This one-to-one mapping was relaxed for this project in a few important cases. Every
DxGroup has a single primary HCC assignment. But certain DxGroups also have secondary or "duplicate" HCC assignments. Duplicate assignments of DxGroups to HCCs occur when certain ICD-9-CM codes denote the presence of more than one clinical condition or disease. An example is DxGroup 131.03 "hypertensive heart/renal disease, with heart/renal failure". This DxGroup is assigned to both HCC 80 "Congestive Heart Failure" and HCC 131 "Renal Failure". A beneficiary assigned to DxGroup 131.03 based on the underlying ICD-9-CM code is appropriately assigned to both heart and renal failure categories.

Considerable clinical detail was added to the DCG/HCC classification system in this project. As Table 3-2 shows, compared to the previous DCG/HCC model (Pope et al., 1998) the number of DxGroups was increased from 545 to 804, and the number of HCCs from 118 to 189. Refinements were made throughout the clinical classification. Examples of new HCCs are HCC 5 "Opportunistic Infections", HCC 20 "Type I Diabetes Mellitus", HCC 27 "Chronic Hepatitis", HCC 54 "Schizophrenia", HCC 95 "Cerebral Hemorrhage", and HCC 150 "Extensive Third Degree Burns". The new classification embodies a more explicit and detailed identification of different types of diseases, and captures a greater range of severity within types of disorders. Further examples are given in the next section.

Descriptive statistics for the 189 HCCs are provided in Tables 3-3 and 3-4. Table 3-3 presents statistics for the HCCs on the prospective sample, when beneficiaries are assigned to HCCs using base year (1996) information. Table 3-4 shows analogous information for the concurrent model in which HCCs are assigned using 1997
information. The "frequency" in Table 3-3 and throughout the report is the number of unique beneficiaries assigned to a HCC based on 1996 information. "1997 person years" refers to the number of months beneficiaries assigned to a HCC are eligible for our sample (see Chapter 2 for sample eligibility rules) divided by 12. If all beneficiaries assigned to a HCC were eligible for the full 12 months in 1997, person years would equal frequency. But primarily because of deaths during 1997, frequency is somewhat greater than person years.

Most HCCs are assigned entirely based on ICD-9-CM diagnosis codes. But as discussed in Chapter 6, for this project we also explore defining several HCCs wholly or partly in terms of durable medical equipment (DME) or procedure utilization. HCCs 185-189 are defined by beneficiary utilization of selected types of DME, such as wheelchairs. HCC 173, Major Organ Transplant, is defined by procedure codes only. Several other HCCs—for example, HCC 181 Chemotherapy—are alternately defined by diagnosis codes only, or by diagnosis codes and analogous procedure and DME codes. In Table 3-3, descriptive statistics are presented for both variants of these HCCs – those using only diagnoses, and those using DME and carefully selected procedure codes.

HCC 129, End Stage Renal Disease (ESRD), is unique in that it is defined by Medicare entitlement status, not by diagnosis, DME, or procedure codes. No data are presented for this HCC because ESRD eligibles were excluded from our analysis sample for this project. However, the ESRD HCC may prove useful in future work involving risk adjustment for the ESRD population.
3.3 Examples

This section presents examples of the new DCG/HCC clinical classification system. We begin, in Table 3-5, with a clinical vignette that illustrates the grouping of ICD-9-CM codes into DxGroups, then DxGroups into Condition Categories (CCs). A 79-year-old woman has diagnoses of acute myocardial infarction (AMI), obstructive chronic bronchitis, interstitial emphysema, and renal failure. Her ICD-9-CM AMI diagnosis is grouped into a DxGroup and a CC for AMI. Her two lung diagnoses are both grouped into the DxGroup for emphysema/chronic bronchitis, which assigns her to HCC 108 Chronic Obstructive Pulmonary Disease (COPD). Her two renal failure diagnoses are grouped into two DxGroups for types of renal failure, which both assign her to the single HCC 131 "Renal Failure". In the end, this woman's 5 ICD-9-CM codes assign her to three HCCs, for AMI, COPD, and Renal Failure. Although not shown in Table 3-5, estimated incremental cost weights are assigned to each of these illnesses (HCCs), which are summed to predict the woman's total expected medical expenditures.

Cancer, heart disease, and cerebrovascular disease are the three greatest killers of Americans. We now present examples of how these three severe, prevalent, and expensive diseases are represented in the DCG/HCC classification system. Table 3-6 shows the DCG/HCC Neoplasm Hierarchy. There are 8 HCCs in the hierarchy, arranged in a strictly hierarchical fashion. A diagnosis assigning a person to a higher-ranked HCC excludes the person from all lower-ranked HCCs. For example, if a person has metastatic cancer or acute leukemia, he or she is assigned to the highest ranked neoplasm HCC and excluded from all others. Only the top 4 HCCs are included in the prospective payment
model. The bottom 4 HCCs, consisting of benign or noninvasive neoplasms, are considered to have definitive treatment (e.g., surgical removal), and therefore are not expected to have significant future cost implications.

The DCG/HCC heart hierarchy is extensive, as might be expected of the disorder that kills far more male and female Americans than any other condition. It includes 15 HCCs altogether, 11 of which are included in the prospective payment model. In Table 3-7, we show selected heart disease HCCs. This table makes the point that 4 different major types of heart disease are cumulative in the heart disease HCCs. Congestive heart failure, coronary artery disease, valvular heart disease, and heart arrhythmias are all considered to contribute independently to a beneficiary's total burden of heart disease. Rather than assigning a beneficiary to just a single heart diagnosis considered to be most severe, the DCG/HCC classification provides a detailed description and cumulation of a beneficiary's types of heart disease.

However, severity of illness of several specific types of heart disease is captured through subhierarchies of HCCs within the overall heart disease hierarchy. As Table 3-7 shows, there are 4 HCCs for coronary artery disease, and 2 for heart arrhythmias. (There is only one HCC for congestive heart failure and one for valvular heart disease.) Table 3-8 shows the 4 coronary artery disease HCCs. They are arranged in a strict hierarchy. For example, a diagnosis of heart attack (AMI) excludes all other ischemic heart disease diagnoses. In short, the DCG/HCC heart disease hierarchy is a mixture of subhierarchies identifying severity of some specific types of heart disease, and an additive cumulation of multiple types of heart disease. A person's total burden, or severity, of heart disease is a
combination both of his or her severity of particular types of heart disease, and the numbers of different types of heart disease present.

Table 3-9 shows the DCG/HCC Cerebrovascular Disease hierarchy, which includes 9 HCCs. All are included in the prospective payment model. The 5 for cerebrovascular disease itself are arranged in a strict hierarchy. A diagnosis of hemorrhagic or ischemic stroke is considered more severe than the other HCCs, for example, cerebral atherosclerosis. In addition, there are 4 HCCs for the late effects of cerebrovascular disease. These are (not shown in Table 3-9): HCC 100 Hemiplegia/Hemiparesis, HCC 101 Diplegia, Monoplegia, and Other Paralytic Syndromes, HCC 102 Speech, Language, Cognitive, Perceptual Deficits, and HCC 103 Cerebrovascular Disease Late Effects, Unspecified. The HCCs for late effects are additive to the HCCs for cerebrovascular disease itself. Thus, a stroke with late effects is considered more severe than a stroke without late effects.

The last example we give is of the mental illness HCCs. This area of the DCG/HCC classification underwent extensive revisions in this project. Table 3-10 shows the 4 domains of mental dysfunction that are identified in the DCG/HCC classification. These 4 domains contribute independently and additively to the total burden of mental illness. Each of the 4 domains encompasses a multi-HCC hierarchy. Table 3-11 shows one subhierarchy of mental illness, the Psychiatric Hierarchy. Seven HCCs are included, ranked in a strict hierarchy. A person can be classified into at most one of these HCCs.

\[2\] The hierarchical relationships among the late effects HCCs are that HCCs 100, 101, and 102 exclude HCC 103, and HCC 100 excludes HCC 101.
The six top-ranked psychiatric HCCs are included in the prospective payment model, but the seventh ("Other Psychiatric Disorders") is not.
Table 3-1

DCG Aggregations of ICD-9-CM Codes

| ICD-9-CM codes (n = 15,000+) | DxGroups (n = 804) | Condition Categories (CCs) (n = 189) | Hierarchies imposed for predictions |

**SOURCE:** Health Economics Research, Inc.
<table>
<thead>
<tr>
<th></th>
<th>Previous All Encounter Model</th>
<th>Revised All Encounter Model</th>
</tr>
</thead>
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<td>DxGroups</td>
<td>545</td>
<td>804</td>
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<tr>
<td>HCCs</td>
<td>118</td>
<td>189</td>
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</table>

**SOURCE:** Health Economics Research, Inc.
Table 3-3
Descriptive Statistics on Prospective HCCs

<table>
<thead>
<tr>
<th>HCC</th>
<th>HCC Label</th>
<th>Frequency</th>
<th>1997 Person Years</th>
<th>1997 Mean Expenditures</th>
<th>Std Err of Mean</th>
<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
</tr>
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<tbody>
<tr>
<td>--</td>
<td>Overall Sample</td>
<td>1,394,701</td>
<td>1,338,647</td>
<td>$5,314</td>
<td>$12</td>
<td>$13,822</td>
<td>260%</td>
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<td>HIV/AIDS</td>
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<td>1,675</td>
<td>11,823</td>
<td>587</td>
<td>24,039</td>
<td>203</td>
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<tr>
<td>2</td>
<td>Septicemia/Shock</td>
<td>16,321</td>
<td>13,911</td>
<td>19,910</td>
<td>305</td>
<td>35,941</td>
<td>181</td>
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<tr>
<td>3</td>
<td>Central Nervous System Infection</td>
<td>4,830</td>
<td>4,523</td>
<td>11,396</td>
<td>351</td>
<td>23,594</td>
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<tr>
<td>4</td>
<td>Tuberculosis</td>
<td>3,319</td>
<td>3,111</td>
<td>10,399</td>
<td>440</td>
<td>24,530</td>
<td>236</td>
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<tr>
<td>5</td>
<td>Opportunistic Infections</td>
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<td>2,001</td>
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<td>6</td>
<td>Other Infectious Diseases</td>
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<td>208,575</td>
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<td>16,826</td>
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<td>7</td>
<td>Metastatic Cancer and Acute Leukemia</td>
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<td>14,182</td>
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<td>Lung, Upper Digestive Tract, and Other Severe Cancers</td>
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<td>Diabetes with Neurologic or Peripheral Circulatory Manifestation</td>
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<td>23,431</td>
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<td>17</td>
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<td>18</td>
<td>Diabetes with Ophthalmologic Manifestation</td>
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<td>18,068</td>
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<td>Diabetes with No or Unspecified Complications</td>
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<td>141,721</td>
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<td>16,925</td>
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<tr>
<td>20</td>
<td>Type I Diabetes Mellitus</td>
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<td>91</td>
<td>22,721</td>
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<tr>
<td>21</td>
<td>Protein-Calorie Malnutrition</td>
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<td>11,107</td>
<td>19,301</td>
<td>318</td>
<td>33,555</td>
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<td>22</td>
<td>Other Significant Endocrine and Metabolic Disorders</td>
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<td>21,669</td>
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<td>87,875</td>
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<td>26</td>
<td>Cirrhosis of Liver</td>
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<td>3,890</td>
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<td>27</td>
<td>Chronic Hepatitis</td>
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<td>1,444</td>
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Health Economics Research, Inc. DCG/HCC Models for Medicare Risk Adjustment: 3-18
Table 3-3 (continued)

Descriptive Statistics on Prospective HCCs

<table>
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<tr>
<th>HCC</th>
<th>HCC Label</th>
<th>Frequency</th>
<th>1997 Person Years</th>
<th>1997 Mean Expenditures</th>
<th>Std Err of Mean</th>
<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Intestinal Obstruction/Perforation</td>
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<td>24,969</td>
<td>13,654</td>
<td>166</td>
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<td>32</td>
<td>Pancreatic Disease</td>
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<td>9,489</td>
<td>12,180</td>
<td>249</td>
<td>24,279</td>
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<td>33</td>
<td>Inflammatory Bowel Disease</td>
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<td>6,773</td>
<td>8,559</td>
<td>235</td>
<td>19,349</td>
<td>226</td>
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<tr>
<td>34</td>
<td>Peptic Ulcer, Hemorrhage, Other Specified</td>
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<td>69</td>
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<td>Gastrointestinal Disorders</td>
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<td>1,473</td>
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<td>571</td>
<td>21,917</td>
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<td>Rheumatoid Arthritis and Inflammatory</td>
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<td>Disorders of the Vertebræ and Spinal Discs</td>
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<td>Congenital/Developmental Skeletal and Connective Tissue Disorders</td>
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<td>17,823</td>
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<td>Other Musculoskeletal and Connective Tissue Disorders</td>
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<td>Disorders of Immunity</td>
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<td>6,906</td>
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<td>28,320</td>
<td>188</td>
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<td>46</td>
<td>Coagulation Defects and Other Specified Hematological Disorders</td>
<td>33,189</td>
<td>30,959</td>
<td>10,831</td>
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<td>47</td>
<td>Iron Deficiency and Other/Unspecified Anemias and Blood Disease</td>
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<td>120,833</td>
<td>9,841</td>
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<td>Senility, Nonpsychotic Organic Brain Syndromes/Conditions</td>
<td>10,676</td>
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<td>18,399</td>
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<td>51</td>
<td>Drug/Alcohol Psychosis</td>
<td>5,290</td>
<td>4,902</td>
<td>13,759</td>
<td>328</td>
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<td>Drug/Alcohol Dependence</td>
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<tr>
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<td>Drug/Alcohol Abuse, Without Dependence</td>
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<td>Major Depressive, Bipolar, and Paranoid Disorders</td>
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<td>Reactive and Unspecified Psychosis</td>
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Table 3-3 (continued)

Descriptive Statistics on Prospective HCCs

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<tr>
<th>HCC</th>
<th>HCC Label</th>
<th>Frequency</th>
<th>1997 Person Years</th>
<th>1997 Mean Expenditures</th>
<th>Std Err of Mean</th>
<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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### Table 3-3 (continued)

**Descriptive Statistics on Prospective HCCs**

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Table 3-3 (continued)

Descriptive Statistics on Prospective HCCs

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<td>Other Urinary Tract Disorders</td>
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<td>Pelvic Inflammatory Disease and Other Specified Female Genital Disorders</td>
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<td>104</td>
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<td>654</td>
<td>6,663</td>
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<tr>
<td>143</td>
<td>Completed Pregnancy With Major Complications</td>
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<td>82</td>
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<td>894</td>
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<td>Completed Pregnancy With Complications</td>
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<td>932</td>
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<tr>
<td>145</td>
<td>Completed Pregnancy Without Complications (Normal Delivery)</td>
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<td>83</td>
<td>4,533</td>
<td>1,085</td>
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Table 3-3 (continued)

Descriptive Statistics on Prospective HCCs

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<th>HCC</th>
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<th>1997 Person Years</th>
<th>1997 Mean Expenditures</th>
<th>Std Err of Mean</th>
<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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<tbody>
<tr>
<td>146</td>
<td>Uncompleted Pregnancy With Complications</td>
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<td>71</td>
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<td>Uncompleted Pregnancy With No or Minor Complications</td>
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<td>305</td>
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<td>Decubitus Ulcer of Skin</td>
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<td>17,655</td>
<td>235</td>
<td>27,491</td>
<td>156</td>
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<td>Chronic Ulcer of Skin, Except Decubitus</td>
<td>25,102</td>
<td>23,395</td>
<td>10,982</td>
<td>130</td>
<td>19,915</td>
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<td>Extensive Third-Degree Burns</td>
<td>45</td>
<td>43</td>
<td>16,380</td>
<td>3,819</td>
<td>24,897</td>
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<tr>
<td>151</td>
<td>Other Third-Degree and Extensive Burns</td>
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<td>460</td>
<td>11,998</td>
<td>1,027</td>
<td>20,162</td>
<td>204</td>
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<tr>
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<td>Cellulitis, Local Skin Infection</td>
<td>99,305</td>
<td>93,393</td>
<td>9,890</td>
<td>66</td>
<td>20,162</td>
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<td>Other Dermatological Disorders</td>
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<td>Severe Head Injury</td>
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<td>Major Head Injury</td>
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<td>10,911</td>
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<td>21,158</td>
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<td>Concussion or Unspecified Head Injury</td>
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<td>486</td>
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<td>Vertebral Fractures</td>
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<td>128</td>
<td>19,587</td>
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<tr>
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<td>Hip Fracture/Dislocation</td>
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<td>11,172</td>
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<td>Major Fracture, Except of Skull, Vertebrae, or Hip</td>
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<td>8,823</td>
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<td>Traumatic Amputation</td>
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<td>2,020</td>
<td>19,371</td>
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<td>Poisonings and Allegic Reactions</td>
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<td>49,368</td>
<td>9,339</td>
<td>87</td>
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<td>164</td>
<td>Major Complications of Medical Care and Trauma</td>
<td>37,154</td>
<td>34,291</td>
<td>13,091</td>
<td>136</td>
<td>25,260</td>
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<td>165</td>
<td>Other Complications of Medical Care</td>
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<td>10,039</td>
<td>165</td>
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<td>166</td>
<td>Major Symptoms, Abnormalities</td>
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<td>Minor Symptoms, Signs, Findings</td>
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<td>17,091</td>
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<td>Serious Perinatal Problem Affecting Newborn</td>
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<td>22</td>
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<td>Major Organ Transplant3</td>
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<td>27,894</td>
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Health Economics Research, Inc. DCG/HCC Models for Medicare Risk Adjustment: 3-23
Table 3-3 (continued)

Descriptive Statistics on Prospective HCCs

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<tr>
<th>HCC</th>
<th>HCC Label</th>
<th>Frequency</th>
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<th>1997 Mean Expenditures</th>
<th>Std Err of Mean</th>
<th>Std. Dev</th>
<th>Coefficient of Variation</th>
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</thead>
<tbody>
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<td>Artificial Openings for Feeding or Elimination (Plus DME and Procedures)²</td>
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<td>9,695</td>
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<td>30,858</td>
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<td>Amputation Status, Lower Limb/Amputation Complications¹</td>
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<tr>
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<td>3,590</td>
<td>16,992</td>
<td>453</td>
<td>27,154</td>
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<tr>
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<td>152</td>
<td>12,086</td>
<td>1,572</td>
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<td>1,092</td>
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<td>Post-Surgical States/Aftercare/Elective</td>
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<td>187,430</td>
<td>8,332</td>
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<td>17,563</td>
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<td>Radiation Therapy¹</td>
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<td>5,057</td>
<td>11,141</td>
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<td>20,247</td>
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<tr>
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<td>11,748</td>
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<td>21,600</td>
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<tr>
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<td>Chemotherapy¹</td>
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<td>346</td>
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<tr>
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<td>13,765</td>
<td>15,976</td>
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<td>23,327</td>
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<td>29,051</td>
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<td>20,444</td>
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<tr>
<td>183</td>
<td>Screening/Observation/Special Exams</td>
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<td>783,518</td>
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<td>14,608</td>
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<td>History of Disease</td>
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<td>17,059</td>
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<td>185</td>
<td>Oxygen</td>
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<td>22,579</td>
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<td>171</td>
<td>25,646</td>
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</tr>
<tr>
<td>186</td>
<td>CPAP/IPPB/Nebulizers</td>
<td>16,220</td>
<td>15,205</td>
<td>11,552</td>
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<td>20,389</td>
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<tr>
<td>187</td>
<td>Patient Lifts, Power Operated Vehicles, Beds</td>
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<td>19,878</td>
<td>19,793</td>
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<td>26,230</td>
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<td>188</td>
<td>Wheelchairs, Commodes</td>
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<td>11,431</td>
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<td>20,382</td>
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</tbody>
</table>

**NOTE:**
¹ Based on diagnosis codes only
² Based on diagnosis, DME, and procedure codes.
³ Based on procedures codes only

**OUTPUT:** D9pr03ab.out, D9pr03ab.ou2, and D9pr05c.out

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare Data.
### Table 3-4

Descriptive Statistics by HCC, Medicare Concurrent Sample, 1997

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<th>HCC</th>
<th>HCC Label</th>
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<th>1997 Mean Expenditures</th>
<th>Std Err of Mean</th>
<th>Standard Deviation</th>
<th>CV</th>
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<td>Overall sample</td>
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<td>1,479,288</td>
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<td>$11</td>
<td>$13,535</td>
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<tr>
<td>No 1997 HCC in base concurrent model</td>
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<td>531</td>
<td>26,140</td>
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<td>2</td>
<td>Septicemia/Shock</td>
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<td>42,164</td>
<td>301</td>
<td>45,549</td>
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<tr>
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<td>Central Nervous System Infection</td>
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<td>Tuberculosis</td>
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<td>2,939</td>
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<td>Opportunistic Infections</td>
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<td>Other Infectious Diseases</td>
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<tr>
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<td>Metastatic Cancer and Acute Leukemia</td>
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<td>8</td>
<td>Lung, Upper Digestive Tract, and Other Severe Cancers</td>
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<td>15,254</td>
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<td>204</td>
<td>25,239</td>
<td>157</td>
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<tr>
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<td>Lymphatic, Head and Neck, Brain, and Other Major Cancers</td>
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<td>19,821</td>
<td>45,549</td>
<td>145</td>
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<tr>
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<td>Breast, Prostate, Colorectal and Other Cancers and Tumors</td>
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<td>14,415</td>
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<td>Other Respiratory and Heart Neoplasms</td>
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<tr>
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<td>Other Digestive and Urinary Neoplasms</td>
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<td>42,447</td>
<td>16,016</td>
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<td>Benign Neoplasms of Skin, Breast, Eye</td>
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<td>25</td>
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<td>15</td>
<td>Diabetes with Renal Manifestation</td>
<td>8,734</td>
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<td>23,708</td>
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<td>27,117</td>
<td>107</td>
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<tr>
<td>16</td>
<td>Diabetes with Neurologic or Peripheral Circulatory Manifestation</td>
<td>36,049</td>
<td>34,289</td>
<td>15,030</td>
<td>145</td>
<td>20,448</td>
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<tr>
<td>17</td>
<td>Diabetes with Acute Complications</td>
<td>11,186</td>
<td>10,377</td>
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Descriptive Statistics by HCC, Medicare Concurrent Sample, 1997

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## Table 3-4 (continued)

Descriptive Statistics by HCC, Medicare Concurrent Sample, 1997

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Table 3-4 (continued)

Descriptive Statistics by HCC, Medicare Concurrent Sample, 1997

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Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: 3-28
Table 3-4 (continued)

Descriptive Statistics by HCC, Medicare Concurrent Sample, 1997

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Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: 3-29
Table 3-4 (continued)
Descriptive Statistics by HCC, Medicare Concurrent Sample, 1997

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<td>19,179</td>
<td>166</td>
</tr>
<tr>
<td>185</td>
<td>Oxygen</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>186</td>
<td>CPAP/IPPB/Nebulizers</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>187</td>
<td>Patient Lifts, Power Operated Vehicles, Beds</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>188</td>
<td>Wheelchairs, Commodes</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>189</td>
<td>Walkers</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
</tbody>
</table>

1 Model 4 of Table 7-1.

OUTPUT: D9cn03b.out and D9cn03m.out.

Table 3-5
Clinical Vignette for DCG/HCC Classification
79 Year Old Woman with AMI, COPD, and Renal Insufficiency

<table>
<thead>
<tr>
<th>ICD-9-CM</th>
<th>DxGroup</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>410.91 AMI of unspecified site, initial episode of care</td>
<td>81.01 AMI, initial episode of care</td>
<td>81 AMI</td>
</tr>
<tr>
<td>491.2 obstructive chronic bronchitis</td>
<td>108.01 emphysema/chronic bronchitis</td>
<td>108 COPD</td>
</tr>
<tr>
<td>518.1 Interstitial emphysema</td>
<td>131.06 renal failure, unspecified</td>
<td>131 Renal Failure</td>
</tr>
<tr>
<td>586 renal failure nos</td>
<td>131.05 chronic renal failure</td>
<td></td>
</tr>
<tr>
<td>585 chronic renal failure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SOURCE: Health Economics Research, Inc.
Table 3-6

Neoplasm Hierarchy

Metastatic Cancer and Acute Leukemia

Lung, Upper Digestive Tract, and Other Severe Cancers

Lymphatic, Head and Neck, Brain and Other Major Cancers

Breast, Prostate, Colorectal and Other Cancers and Tumors

Included

Other Respiratory and Heart Neoplasms

Other Digestive and Urinary Neoplasms

Other Neoplasms

Excluded

Benign Neoplasms of Skin, Breast, Eye

Included

Excluded

Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: 3-32
Table 3-7

Selected Heart Disease HCCs

SOURCE: Health Economics Research, Inc.
Table 3-8

Coronary Heart Disease HCCs

- Acute Myocardial Infarction
  - Unstable Angina and Other Acute Ischemic Heart Disease
    - Angina Pectoris/Old Myocardial Infarction
      - Coronary Atherosclerosis/Other Chronic Ischemic Heart Disease

SOURCE: Health Economics Research, Inc.
Table 3-9
Cerebrovascular Disease HCCs

Cerebral Hemorrhage

Ischemic or Unspecified Stroke

Precerebral Arterial Occlusion and Transient Cerebral Ischemia

Cerebral Atherosclerosis and Aneurysm

Cerebrovascular Disease, Unspecified

Cerebrovascular Disease, Late Effects (4 HCC hierarchy)

SOURCE: Health Economics Research, Inc.
Table 3-10
Mental Illness HCCs

<table>
<thead>
<tr>
<th>Cognitive Disorders (3 HCCs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
</tr>
<tr>
<td>Drug/Alcohol Abuse (3 HCC Hierarchy)</td>
</tr>
<tr>
<td>+</td>
</tr>
<tr>
<td>Psychiatric Disorders (7 HCCs)</td>
</tr>
<tr>
<td>+</td>
</tr>
<tr>
<td>Mental Retardation/Developmental Delay (6 HCC hierarchy)</td>
</tr>
</tbody>
</table>

**SOURCE:** Health Economics Research, Inc.
Table 3-11
Psychiatric HCCs

Schizophrenia

Major Depressive, Bipolar, and Paranoid Disorders

Reactive and Unspecified Psychosis

Personality Disorders

Depression

Anxiety Disorders

Other Psychiatric Disorders

Included

Excluded

SOURCE: Health Economics Research, Inc.
In this chapter, we use the Medicare 1996/1997 5 percent sample analytic data described in Chapter 2 to estimate, develop, refine, and evaluate DCG/HCC prospective diagnosis-based risk adjustment models. A series of regression models are fit to the data, modified to enhance clinical credibility, and examined for their performance as risk adjustment models. We calculate measures of predictive accuracy of models at the individual level and for significant subgroups of Medicare beneficiaries.

We first fit a simple age/sex model to serve as a baseline. Then we add two additional demographic markers (presence of a state Medicaid “buy-in” and “originally-disabled”) and dummy markers for each Hierarchical Condition Category (HCC) diagnostic category. We next examine different payment weights for Medicare beneficiaries currently entitled by disability, and exclude discretionary diagnoses and constrain certain coefficients to preserve monotonicity (see Chapter 3). Then we examine interactions among diagnostic categories and select a few for inclusion in our base model. Once the base model is established, its predictive accuracy is evaluated for a set of subgroups of the Medicare population. Finally, the Medicaid and originally disabled demographic factors are calibrated by age/sex category for the base model, and a payment multiplier for the "working aged" Medicare subpopulation is calibrated.
4.1 **Age/Sex Model**

In every prospective model, regression is used to predict total 1997 Medicare expenditures from a set of predictors that include 24 age/sex cells. We first estimated the model with only these age and sex predictors (Table 4-1). Consistent with previous research, the age/sex model explains about 1 percent of variation in Medicare expenditures among individual enrollees (e.g., Ellis *et al.*, 1996). Nevertheless, mean expenditures differ substantially by age/sex cell, ranging from $3,292 for 0-34 year old males to $9,262 for 89-94 year old males. Medicare expenditures rise with age, with two exceptions. The oldest of the under-age-65 people who are entitled to Medicare because of disability are more expensive than the 65-69 year-olds (the vast majority of whom are not disabled). Also, expenditures peak for both males and females at age 89-94. Among beneficiaries entitled by disability (those under age 65), expenditures are greater for females than males. But elderly male Medicare beneficiaries are more expensive than equally old females.

4.2 **Adding Diagnoses**

In Model 1 of Table 4-2, we add HCC diagnostic categories to the age/sex model\(^1\). Beneficiaries are marked for having any number of distinct medical problems (HCCs) on the basis of their 1996 diagnoses. We also include markers for two new demographic factors: 1996 Medicaid enrollment and originally-disabled status.

---

\(^1\) HCCs 185-189 and 173 are based on DME and procedures, respectively, and are not considered until Chapter 6.
This model explains fully 11.54 percent of the variation in 1997 expenditures. Not surprisingly, the age/sex coefficients in this model are lower than in the age/sex model because they now represent the costs of people with no serious diagnosed medical problems in the previous year. Medicaid and originally-disabled markers have substantial coefficients of $810 and $1,261, respectively.

Most diagnostic categories (HCCs) have coefficients that are either positive or essentially zero. But a few diagnoses have coefficients that are significantly negative. The reasons for significant negative coefficients are not clear, but could range from substitution of Medicaid services for Medicare (e.g., mental retardation?), underservice (e.g., mental retardation?), correlation of certain diagnoses with age and either unmeasured better health among younger age groups or less intensive treatment of older age groups (e.g., appendicitis? genital disorders? cataract? hearing loss?), to possible use of certain "diagnoses" coded during visits with essentially well patients (e.g., high cholesterol?, which is included in HCC 24 Other Endocrine/Metabolic/Nutritional Disorders). As discussed below, we chose to exclude all variables with negative coefficients.

### 4.3 Adding “Disabled” Interactions

Approximately 12 percent of Medicare beneficiaries are entitled to Medicare because they are under 65 years of age and have a medical condition that prevents them from working (these are the “disabled”). At age 65, these beneficiaries become entitled to Medicare because of age (and we designate them as “aged” and “originally disabled”).
Clinically, it is plausible that the nature and severity of some diagnoses might differ between the disabled and the elderly. For example, a diagnosis that is a disabling condition may be more severe. The accuracy of prediction and clinical validity of a risk adjustment model may be improved by allowing some differences between the disabled and aged. Thus, we considered allowing coefficient differences for some diagnoses (HCCs) for the Medicare subpopulation entitled by disability.

Ideally we would calibrate the model separately on aged and disabled subsamples. But the subsample of beneficiaries entitled by disability in our 5 percent sample was not large enough to permit this, and we leave completely separate calibration for future work. However, we can obtain information about disabled/elderly parameter differences by estimating the model by subpopulation with the sample we do have, and comparing coefficients.

In Table 4-3, we present the results of a comparison of HCC coefficients estimated separately on aged and disabled subpopulations using our 5 percent sample. Table 4-3a shows aged and disabled sample sizes by HCC. We evaluated coefficient differences for inclusion in the prospective DCG/HCC risk adjustment model. The criteria we used to evaluate differences were:

- magnitude of difference;
- statistical significance of difference;
- clinical plausibility/significance of difference;
- number of aged and disabled beneficiaries involved in the comparison; and
- inclusion of the diagnostic category (HCC) in the prospective payment model.
Because we are making multiple comparisons, and because of the possibility of overfitting due to expenditure outliers, we focussed on differences with a t-statistic of more than 4. Among these differences, we included those that have the most clinical plausibility and significance. In addition, we included several differences with smaller t-statistics because of other considerations discussed below. We also consulted our previous analysis of aged/disabled differences with the 1991/1992 database (Pope et al., 1998) for validation of differences.

The 9 aged/disabled differences we included in the model are shown in Table 4-4. Table 4-3 shows a large and statistically significant coefficient difference for HCC 1, HIV/AIDS. Moreover, this was a difference included in our previous DCG/HCC model (Pope et al., 1998). But the negative aged parameter estimate (which is insignificantly different from zero) is implausible. Therefore, we chose to not allow an aged/disabled difference for HIV/AIDS, but instead to allow one for HCC 5, Opportunistic Infections, which frequently occur among HIV/AIDS patients. Several large and statistically significant differences exist for HCCs not included in the payment model, such as for HCC 23 Disorders of Fluid/Electrolyte/Acid-Base Balance (Table 4-3). But we did not allow coefficient differences for the disabled because these diagnoses are not included in our payment model (see Chapter 3 for discussion of why certain diagnoses are excluded from payment models).

We included aged/disabled differences for all three HCCs in the "hematological" hierarchy included in the payment model, HCCs 44, 45, and 46. The aged/disabled difference is particularly pronounced for HCC 44 Severe Hematological Disorders, which
includes hemophilia and sickle cell anemia. The aged/disabled differences are less pronounced for the other two hematological HCCs, especially HCC 45 Disorders of Immunity, but allowing differences for all three HCCs accurately captures expenditure differences among these related HCCs for both aged and disabled populations. Differences in costs for hematological disorders were also allowed in our previous analysis of the 1991/1992 dataset (Pope et al., 1998).

In the mental health area, aged/disabled differences were allowed for substance abuse (both psychoses and dependence) and for Schizophrenia. These differences were also allowed in our previous DCG/HCC model (Pope et al., 1998). However, Major Depressive, Bipolar, and Paranoid Disorders (HCC 55) have lower estimated incremental costs among the disabled than the elderly. No difference was permitted here because of concerns about clinical plausibility.

The two additional aged/disabled differences that we incorporated are for multiple sclerosis (HCC 72) and cystic fibrosis (HCC 107). The cystic fibrosis difference has a t-statistic of less than 4, and sample sizes are quite small. However, this difference is large and clinically plausible, because the most severe cystic fibrosis cases are not expected to survive until age 65. Validation of this difference in additional datasets is desirable.

When added to the regression model, the 9 disabled interaction terms increase the percentage of expenditure variation explained only slightly (11.54% and 11.57% are the R-squares for Models 1 and 2 in Table 4-2, respectively). This is partly because the disabled comprise only a small proportion (around 12 percent) of the Medicare population. But the coefficient estimates of the disabled interactions are substantial and
Chapter 4 Diagnosis-Based Risk Adjustment Models

statistically significant, ranging from $1,390 for schizophrenia to $6,079 for cystic fibrosis. Table 4-4 shows that the incremental payments for these 9 conditions are substantially different for the aged and disabled\(^2\). We conclude that although predictive power is raised only slightly, these selected interactions should be included in the model to improve its payment accuracy and face validity for important subgroups of disabled Medicare beneficiaries.

4.4 Exclusions and Constraints

The next step in our analysis was to impose diagnostic exclusions and constraints on estimated coefficients. This is reflected in Model 3 of Table 4-2. As discussed in Chapter 3, discretionary diagnoses, as determined by clinical judgment, are excluded from prospective payment models. We excluded any remaining diagnoses with negative coefficient estimates because we do not want to penalize health plans for recording diagnoses (the principle of monotonicity—see Chapter 3).

Also to satisfy monotonicity, in cases where diagnostic hierarchies are violated, we constrained coefficients. A diagnostic hierarchy is "violated" when the estimated coefficient a higher-ranked condition (HCC) is smaller than the estimated coefficient of a lower-ranked HCC in the same hierarchy. In these cases, the coefficients of the higher- and lower-ranked HCCs are constrained to be the same. In Table 4-2, these constraints are indicated by vertical bars. For example, in Model 2, the coefficient of HCC 26

\(^2\) The incremental payments in Table 4-4 are derived from the coefficients of the "base" model, Model 5 in Table 4-2. The base model is discussed below in Section 4.6.
Cirrhosis of Liver, $1,831, is smaller than the coefficient of HCC 27 Chronic Hepatitis, $1,837. But HCC 26 is higher-ranked than HCC 27 in the "liver" hierarchy. Therefore, in Model 3, the coefficients of HCCs 26 and 27 are constrained to be equal. The estimated constrained coefficient of $2,035 for this pair is a modest increase over the two coefficients separately, and reflects the exclusion of many other diagnoses (HCCs) from Model 3.

Altogether, the exclusions and constraints reduce the number of model parameters from 217 in Model 2 to 122 in Model 3 (Table 4-2). This represents a reduction of 44 percent in the number of parameters. Nevertheless, the percentage of individual expenditure variation explained (R-Square) falls only from 11.57 percent to 11.10 percent. Although excluding discretionary diagnoses and imposing constraints does sacrifice predictive power, the loss is relatively limited. We believe that this is a tradeoff worth making, that is, sacrificing a limited amount of predictive ability to improve model incentives and fairness as a payment system.

4.5 Adding Diagnosis Interactions

As discussed in Chapter 3, the DCG/HCC model captures the combined effect of multiple unrelated conditions by accumulating the sum of their individual effects. For example, the model postulates that the combined incremental costs of diabetes and congestive heart failure is the sum of the incremental cost of diabetes alone, and of the incremental cost of congestive heart failure alone. The assumption of additivity is empirically testable. The combined effect of multiple diagnoses need not equal the sum
of their individual effects. If the additivity assumption does not hold for a particular combination of diseases, the predictive accuracy and clinical face validity of the risk adjustment model can be improved by incorporating these nonlinearities.

We implement the empirical test of the additivity assumption through the use of "interaction terms" in the multiple regression analysis. Interaction terms allow the combined effect of multiple diagnoses to differ from their individual effects. If the combined effect is greater than the sum of the individual effects, the interaction term will be positive. If the combined effect is less than the sum of the individual effects, the interaction term will be negative. Operationally, to test an interaction between diabetes and congestive heart failure for example, individual variables for the two conditions separately continue to be included in the model, but an interaction term identifying beneficiaries diagnosed with both conditions is also included.

The number of possible interaction terms among all HCCs is extremely large. It is not possible to empirically test all two-way interactions, let alone higher-order interactions. Moreover, the frequency of many interactions is so low that it would not be feasible to test all possible interactions. Thus, we maintain the assumption that most interaction terms are zero, and focus our tests for interaction effects on a small number of common, high-cost conditions. We identified 6 high-cost chronic conditions that are commonly diagnosed in the Medicare population, and that our clinical panel expected might exhibit nonzero interactions. They are:

1. diabetes (HCCs 15-20);
2. congestive heart failure (HCC 80);
Chapter 4 Diagnosis-Based Risk Adjustment Models

3. coronary artery disease (HCCs 81-84);
4. cerebrovascular disease (HCCs 95-103);
5. vascular disease (HCCs 104-105); and
6. chronic obstructive pulmonary disease (HCC 108).

Note that several of these conditions encompass multiple HCCs; in these cases any beneficiary classified into any one of the HCCs is classified as having the condition.

We began by examining all 57 2-, 3-, 4-, 5-, and 6-way interactions among these 6 conditions. We found that none of the 4-, 5-, and 6-way interactions were significant enough to include in the DCG/HCC model. Therefore, we focussed on the 35 2- and 3-way interactions among the 6 conditions. In addition, we examined the 3 2- and 3-way interactions of diabetes and congestive heart failure with renal failure (HCC 131), for a total of 38 interactions. (We examined only limited renal failure interactions because it has a relatively small sample size.)

Descriptive statistics for the 38 diagnosis interactions we examined are shown in Table 4-5. The diagnosis combinations that occur most frequently involve coronary artery disease, which is itself very frequent in the Medicare population. The most frequent combination is coronary artery disease and congestive heart failure, which occurs in 95,980 beneficiaries, or about 7 percent of the sample of 1.4 million. Many of the 2-way interactions occur in 30,000 to 70,000 sample beneficiaries. Three-way interactions are less frequent, occurring in 10,000 to 30,000 sample beneficiaries. The combination of diabetes, congestive heart failure, and renal failure occurs in only 5,210 beneficiaries. Expenditures are higher with the presence of more comorbid conditions.
For example, the 47,995 beneficiaries diagnosed with diabetes and congestive heart failure in 1996 have mean 1997 expenditures of $15,962, but the 15,204 of these beneficiaries also diagnosed with chronic obstructive pulmonary disease have average expenditures of $20,322.

In Model 4 of Table 4-2, we add all 38 diagnosis interaction terms to Model 3 of that table. Strikingly, the percentage of expenditure variation explained (R-square) increases barely at all, from 11.10 percent to 11.16 percent. Allowing the combined effect of conditions to differ from the sum of their individual effects improves predictive power only slightly. To be sure, we examined only a few of the many possible diagnosis interactions among our HCCs. But the interactions we studied are among the most frequent and high cost Medicare conditions. We find it implausible that the interactions we did not analyze would add substantially more predictive power than the ones we did analyze. We conclude that our maintained assumption of additivity, at least from the perspective of predictive power, is well-supported empirically. Purely from the perspective of predictive power, there is little reason to add any interaction terms to the model.

However, some of the estimated coefficients of the interaction terms are substantial in magnitude and statistically significant (see Model 4 of Table 4-2). This suggests that adding certain diagnosis interaction terms to the model will improve its predictive accuracy for important subgroups and clinical face validity. We evaluated diagnosis interactions for inclusion in the model using three criteria:

- magnitude of interaction;
Because we are making multiple comparisons, and to guard against overfitting, we focussed on interaction terms with t-statistics of 4 or greater. Among the 38 interactions, 6 have t statistics of 4 or more. We chose to include all 6 in our base payment model.

The 6 included diagnosis interactions are summarized in Table 4-6. Although this need not be true, all 6 interactions are positive, that is, the combined effect of the multiple diagnoses exceeds the sum of their individual effects. The largest interaction effects are among congestive heart failure (CHF) and chronic obstructive pulmonary disease (COPD), and among diabetes, CHF, and renal failure.

### 4.6 Base Payment Model

Model 5 of Table 4-2 is our base prospective risk adjustment payment model. It incorporates the following elements:

- 24 age/sex cells;
- prior year Medicaid enrollment;
- originally disabled status;
- 101 HCC diagnostic categories;
- 12 coefficient constraints involving 27 diagnostic categories (HCCs);
- 9 diagnosis payment differences for beneficiaries currently entitled by disability; and
- 6 payment differences for combinations of diagnoses.
Our base model does not include any procedure or durable medical equipment (DME) codes. It is defined from demographic information available in Medicare enrollment files and ICD-9-CM diagnosis codes only.

In the remainder of this report, we use Model 5 of Table 4-2 as our baseline against which alternative models are compared and evaluated. We note that the R-square of our base model is 11.15 percent. This is the R-square on the estimation sample. Previous experience (Ellis et al., 1996; Pope et al., 1998) indicates that the R-square will be roughly 10 percent lower in a validation sample, so a validation R-square of approximately 10 percent or slightly higher may be expected. We also remind the reader that all R-squares in this report are estimated using 1996/1997 Medicare fee-for-service data; they may differ when other years of data or populations are analyzed. In particular, the predictive accuracy of these models for the Medicare managed care population is unknown.

4.7 Accuracy of Base Model for Medicare Subgroups

It is desirable to evaluate the predictive accuracy of risk adjustment models for the mean expenditures of important subgroups of populations, as well the percentage of individual expenditure variation predicted. Health plans may select enrollees based on observable characteristics of subgroups, or have disproportionately few or many of certain subgroups of beneficiaries based on their characteristics (e.g., provider networks or geographic locations). For these reasons, it is important to predict accurately for
subgroups to ensure their access to care and fairness in payment to the health plans enrolling them.

### 4.7.1 Definition of Validation Groups

We defined a large number of subgroups of the Medicare population to use in measuring the accuracy of our risk adjustment models. They are shown, together with descriptive statistics for them, in Table 4-7. The "validation groups" are divided into demographic groups, groups diagnosed with certain conditions, groups diagnosed with certain combinations of conditions, groups with certain ranges or types of prior year (1996) or prediction year (1997) expenditures, groups utilizing certain types of durable medical equipment (DME) in the base year (1996), and groups with certain numbers of hospital admissions in the base (1996) or prediction (1997) years.

Many of these Medicare subgroups have been used in our previous work (Ellis et al., 1996; Pope et al., 1998). Innovations for this project are in the definition of groups with multiple diagnoses, with home health or DME expenditures, and with DME utilization. Adding groups with combinations of diagnoses aids in evaluating the predictive accuracy of alternative models for beneficiaries with multiple diagnoses. Beneficiaries with high home health or DME expenditures or utilization are more likely to be functionally impaired. Adding these groups allows a partial evaluation of how well models predict expenditures for functionally impaired beneficiaries, without using survey data such as the Medicare Current Beneficiary Survey.
The diagnosis-based validation groups were assigned using diagnoses from hospitals, physicians, clinically-trained nonphysicians, and facility types including home health agencies, ambulatory surgery centers, skilled nursing facilities, and hospice (Source=1-6, see Chapter 2). This differs from the diagnoses used to calibrate our risk adjustment models in this chapter, which consist of hospital, physician, and clinically-trained nonphysician diagnoses only (Source=1-5). We defined the validation groups including the additional facility diagnoses to make the prediction of expenditures for these groups more challenging. It is not surprising that our risk adjustment models predict expenditures almost exactly for validation groups defined using the same sources of diagnoses because most of the diagnoses are explicitly included in the risk adjustment models. Evaluating model performance for groups defined using additional sources of diagnoses is more informative. Chapter 5 contains a thorough evaluation of the sensitivity and accuracy of our models calibrated using different diagnosis sources.

4.7.2 Measuring Predictive Accuracy for Groups

For this project, we did not divide our sample into an "estimation sample" and a "validation sample". Instead, we chose to use our entire 5 percent sample for model development and estimation. This was done because we needed the largest possible sample sizes to estimate the expenditures of rare diseases, and to analyze disabled and diagnostic interaction terms. We also use the entire 5 percent sample for validation. Because we validate on the same sample as we estimated on, our results are likely to slightly overstate the true predictive accuracy of our models. Previous experience
indicates that this model "overfitting" is present with the sample sizes and number of model parameters that we employ, but not very large (e.g., on the order of 10 percent with R-square—see Ellis et al., 1996, Pope et al., 1998, and Pope et al., 1999). However, in this project we estimate models with larger numbers of parameters than previously because of the additional clinical detail of our classification system (more HCCs), and because of our added disabled and diagnosis interaction terms. Overfitting becomes more of a concern as the number of categories with smaller sample sizes rises. Nevertheless, we believe that the "validation" results presented in this report represent an accurate, albeit slightly overstated, indication of the predictive accuracy of our models.

Percentage of individual expenditure variation predicted is measured by the R-square statistic, while predictive accuracy for groups is measured by the "predictive ratio". The predictive ratio is the ratio of mean predicted expenditures to mean actual expenditures. A predictive ratio of 1.00 indicates precisely accurate prediction; a ratio less than 1.00 indicates underprediction; and a ratio of more than 1.00 indicates overprediction.

4.7.3 Results

Table 4-8 shows predictive ratios for three risk adjustment models:

- age/sex, based on Table 4-1.
- the "all HCC model", based on Model 1 of Table 4-2. It includes age, sex, prior year Medicaid enrollment, originally disabled status, and all HCC diagnostic categories.
- the base DCG/HCC model, Model 5 of Table 4-2, which includes the elements discussed in Section 4.6 above.
As expected, all three models predict exactly for all enrollees, aged/disabled, and the age/sex cells. It is a property of the multiple linear regression technique used to estimate the models that it predicts the mean of the dependent variable (1997 expenditures) accurately. Age/sex cells are included in the models, and thus they are also predicted accurately. Aged versus disabled current entitlement status is defined exactly by age under 65 versus 65 and over. Given the age cells included in the models, the difference in mean expenditures by entitlement status is also predicted exactly. Medicaid and originally disabled are substantially underpredicted in the age/sex model, but predicted exactly in the other two models, where they are included variables. Race, on the other hand, is not included in any of the models, and mean expenditures for blacks are slightly overpredicted.

Mean expenditures for beneficiaries diagnosed with certain illnesses are severely underpredicted by the age/sex model. But the all HCC and base HCC models, which adjust for diagnoses, predict most quite accurately. Some of the slight underprediction is due to the definition of the validation groups including non-hospital facility diagnoses (e.g., home health agency) whereas the HCC models were calibrated excluding these diagnoses (see Section 4.7.1 above). A few diagnoses are predicted relatively less accurately by the HCC models, although still much better than the age/sex model. These include depression (underpredicted), breast cancer (overpredicted), and lung/pancreas cancer (underpredicted). Arthritis is predicted well by the all HCC model, but less accurately by the base HCC model. This is because arthritis is one of the "discretionary" diagnoses excluded from the base model (see Chapter 3).
The HCC models also predict the mean expenditures of beneficiaries with combinations of diagnoses much more accurately than the age/sex model. The all HCC model (which does not include any special adjustments for multiple diagnoses) predicts quite credibly for combinations of the diagnoses. But the base HCC model, which incorporates diagnostic "interaction" terms (see Section 4.5), predicts even more accurately. For example, the all HCC model underpredicts the mean expenditures of beneficiaries with diabetes, heart failure, and renal failure by 12 percent, while the base HCC model underpredicts by only 2 percent.

Among prior year expenditure quintiles, the all HCC model predicts more accurately than the base HCC model. This is the price that is paid for excluding discretionary diagnoses in the base HCC model. Note that the biggest differences in accuracy of prediction are at the low expenditure end, which is more associated with discretionary diagnoses. Among the top 1 percent of prior year expenditures, the base HCC model does as well as the all HCC model, because these beneficiaries are presumably suffering from very serious, life threatening illnesses that are included in both models.

When percentiles of 1997 expenditures of all types (total, home health or DME) are used all models predict poorly. This is consistent with the finding that 90% of all variation in spending the following year is inherently random and unpredictable. What matters most for risk adjustment models is their ability to match payments to expected costs, not actual costs. For further discussion, see Ellis et al., 1996b and Pope et al., 1998c.
Only 10 percent of prospective sample beneficiaries utilize any prior year (1996) home health services (Table 4-7). But those with any spending are on average very expensive in the following year (1997). Mean 1997 total expenditures for the entire prospective sample are $5,314, but $15,359 (nearly three times as much) for 1996 home health utilizers (Table 4-7). Mean 1997 total expenditures for beneficiaries with prior year home health spending are underpredicted by about 60 percent by the age/sex model (Table 4-8). The HCC models reduce this substantially, but there is still about a 25 percent underprediction of total expenditures, on average. The extent of total expenditure underprediction increases with greater prior year home health spending (Table 4-8). The HCC models predict mean total expenditures accurately for beneficiaries in the first and second quintiles of prior year home health expenditures, but predict only about a third of mean total expenditures for those beneficiaries with the highest prior year home health expenditures.

About 16 percent of the prospective sample has nonzero prior year DME utilization (Table 4-7). As is true of home health utilizers, total expenditures for DME utilizers are well above average, $11,356 in 1997 versus $5,314 for the entire sample (Table 4-7). The HCC models also underpredict mean total expenditures for DME utilizers (Table 4-8). Similar to home health utilization, the underprediction is greater for beneficiaries with higher prior year DME utilization. Overall, however, the underprediction of total expenditures is not as large as it is with home health utilizers: 18 percent on average for DME utilizers versus 25 percent for home health utilizers in the base HCC model. Expenditures are also underpredicted for beneficiaries utilizing
particular types of DME in the base year—oxygen, wheelchairs, and walkers—although the diagnosis-based HCC models do considerably better than the age/sex model.

Home health and DME utilizers are subsets of beneficiaries whose following year total expenditures are substantially underpredicted by diagnosis-based models. This is perhaps not surprising. Home health and DME utilization is presumably related to poor functional status, and it has previously been shown that diagnosis-based models underpredict expenditures for the functionally impaired (Pope et al., 1998). A diagnosis of multiple sclerosis, for example, does not distinguish between those who are only mildly affected by the disease, and those who are highly impaired by it. We will investigate in Chapters 5 and 6 of this report whether the HCC model's underprediction can be reduced by including diagnoses from home health claims in assigning diagnostic categories (Chapter 5), or including utilization of DME as a risk adjuster (Chapter 6).

Hospital admissions groups were the last set of validation groups we examined. Table 4-8 shows that the HCC models predict accurately across groups of beneficiaries defined by number of prior year admissions, except for an underprediction for those with 3 or more admissions.

4.8 Calibration of Medicaid and Originally Disabled Factors by Age/Sex Category

The effects of prior year Medicaid enrollment and originally disabled status on expenditures may vary across the 24 age/sex cells. In other models estimated for this report, for simplicity we include only a single Medicaid and a single originally disabled
factor, independent of age and sex. The purpose of this section is to investigate differences in these effects by age and sex in the base model, Model 5 of Table 4-2.

Table 4-9 presents estimates of the base HCC model with Medicaid and originally disabled interacted with each of the 24 age/sex cells. In addition, the number of observations in each interacted category is listed. Some instabilities in the coefficient estimates occur because of small sample sizes. The sample sizes are useful should actuarial smoothing of the demographic coefficient estimates be undertaken (as was done for the PIP-DCG model, see Pope et al., 1999).

The effect of Medicaid is smaller among the youngest and oldest Medicare age groups. The effect of originally disabled may also decline among the oldest age groups, although there are virtually no sample beneficiaries originally entitled by disability age 89 or older. Differences in the effects of Medicaid and originally disabled by sex are not pronounced, but there appears to be some tendency for their impacts to be higher among women in many age ranges.

Allowing the effect of Medicaid to vary by age results in more plausible coefficient estimates for some of the age/sex cell coefficients. For example, in the base model (Model 5 of Table 4-2), the parameter estimate for "male, 0-34" is only $211. This is a very low estimate of the annual medical expenditures of beneficiaries in this cell, albeit it would only apply to beneficiaries without any diagnoses included in the

---

3 Beneficiaries originally entitled by disability who turn 65 in 1997 will receive fractional values for both the age cell 65-69, and for the original disability status variable. The interaction between these two variables would result in a squared fraction which is less preferred than using the fraction without squaring. For this model we have avoided this problem by setting the originally disabled variable equal to 1 for these beneficiaries.
base model, and not Medicaid-enrolled. When the effect of Medicaid is estimated specifically for this cell, the age-sex coefficient rises to $681, a more plausible value (Table 4-9). When the single estimated Medicaid impact of $927 is applied to all age ranges (Table 4-2), the age/sex coefficient for male 0-34 is forced to an implausibly low value. When the more accurate Medicaid effect of $260 is estimated for this age/sex cell (Table 4-9), the age/sex coefficient assumes a more reasonable value.

### 4.9 Calibration of a Working Aged Multiplier

Working aged refers to aged Medicare beneficiaries (age 65 years or more) with private group health insurance coverage from their or their spouse’s employer. Medicare expenses are much less for the working aged than the non-working aged because, by law, their private group health insurance is the primary payer for their medical care. For this reason, working aged beneficiaries were excluded from the prospective sample used to estimate and validate models (see Chapter 2).

To predict payments for the working aged, we use a "second stage" multiplier (see Pope et al., 1999, Chapter 6 for more discussion). Expenditures are first predicted using the base prospective payment model (Model 5 of Table 4-2). Predicted expenditures are then multiplied by a fraction to adjust them downwards for working aged status. This fraction is applied to predicted payments for any months a beneficiary is in working aged status in the prediction year (1997 in our sample).

Table 4-10 shows mean actual and predicted 1997 expenditures by age and sex for the working aged sample. Overall, actual expenditures for the working aged are about
29 percent of expenditures predicted by the base model. The expenditure ratio is higher for females than males, and tends to increase with age. But variations in the expenditure ratio by age and sex are relatively limited, suggesting that a single multiplier for all age/sex groups is sufficiently accurate.

An analysis of an unbiased multiplicative adjustment was conducted in one of our previous projects (Pope et al., 1999, Chapter 6). The unbiased multiplier predicts expenditures for the working aged correctly on average. The formula to calculate an unbiased multiplier for working aged is as follows (see details, Pope, 1999, Chapter 6):

\[ \beta_{wa} = \left( \frac{APY97TAD - PEXP97}{WAF97AD \times PEXP97} \right) + 1 \]

where

\[ \beta_{wa} \] is a multiplier for working aged months,

\[ APY97TAD = \text{mean of actual annualized expenditures in 1997}, \]

\[ PEXP97 = \text{mean of predicted annualized expenditures in 1997}, \]

and

\[ WAF97AD = \text{fraction of 1997 sample eligible months in working aged status}. \]

Inserting the necessary data from our 1996/1997 working aged sample,

\[ \beta_{wa} = \left( \frac{1188.84 - 3343.60}{2986.86} \right) + 1 = 0.2786. \]

Rounding to two decimal places, we have

\[ \beta_{wa} = 0.28. \]

---

4 The means of APY97TAD, PEXP97, and WAF97AD*PEXP97 for the working aged are from computer output D9PR23A.OUT. The weighting variable is ELFR97AD.
This multiplier is slightly higher than the multiplier of 0.21 that we calculated for the PIP-DCG model (Pope et al., 1999, Chapter 6).

The accuracy of open-ended working aged spells in HCFA's administrative data is open to question. Many of these spells may have ended, but the ending date was never collected and recorded in HCFA's database. We tested the sensitivity of our working aged multiplier by imposing a 5 year time limit on working aged spells. Using the modified data, we recalculate the multiplier as

\[
\beta_{wa} = \frac{(1338.43 - 3244.95)}{2635.95} + 1 = 0.2767.5
\]

Rounding to two decimal places, we have

\[
\beta_{wa} = 0.28.
\]

The multiplier when spells are limited to 5 years is the same to two decimal places. For months in which a beneficiary is in working aged status, the payment formula is

\[
0.28 \cdot \frac{\text{base prospective model predicted expenditure}}{12}.
\]

---

5 The means of APY97TAD, PEXP97, and WAP97AD5*PEXP97 for the working aged up to 5-year are from computer output D9PR25D.OUT. The weighting variable is ELFR97AD.
### Table 4-1

**Age/Sex Model**

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<tr>
<th>Variable</th>
<th>Parameter</th>
<th>Estimate</th>
<th>t-ratio</th>
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**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
Table 4-2
Hierarchical Condition Categories Prospective Risk Adjustment Models

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<th>Parameter Estimate</th>
<th>t-ratio</th>
<th>Parameter Estimate</th>
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<td>29.40</td>
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</table>

HCC1 HIV/AIDS | 3,398 | 10.47 | 2,511 | 7.51 | 2,674 | 7.99 | 2,681 | 8.01 | 2,676 | 7.99 |

HCC2 Septicemia/Shock | 3,029 | 25.53 | 3,023 | 25.49 | 3,543 | 30.29 | 3,517 | 30.06 | 3,518 | 30.09 |

HCC3 Central Nervous System Infection | 935 | 4.80 | 916 | 4.70 | 1,065 | 5.46 | 1,082 | 5.55 | 1,075 | 5.51 |

HCC4 Tuberculosis | 663 | 2.83 | 650 | 2.78 | 651 | 2.77 | 701 | 2.99 | 693 | 2.96 |
<table>
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<td>337 10.01</td>
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<td>Metastatic Cancer and Acute Leukemia</td>
<td>6,548 56.41</td>
<td>6,578 56.66</td>
<td>7,832 70.24</td>
<td>7,876 70.64</td>
<td>7,871 70.60</td>
<td>7,871 70.60</td>
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<td>Lung, Upper Digestive Tract, and Other Severe Cancers</td>
<td>3,676 28.96</td>
<td>3,702 29.17</td>
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<td>33.38 4,237</td>
<td>33.61 4,237</td>
<td>33.61 4,237</td>
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<td>HCC10</td>
<td>Breast, Prostate, Colorectal and Other Cancers and Tumors</td>
<td>649 13.57</td>
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<td>21.60 991</td>
<td>21.97 990</td>
<td>21.97 990</td>
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<td>HCC11</td>
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<td>97 1.36</td>
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<td>Benign Neoplasms of Skin, Breast, Eye</td>
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<td>Diabetes with Renal Manifestation</td>
<td>4,607 22.81</td>
<td>4,611 22.83</td>
<td>4,796 23.70</td>
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<tr>
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<td>Diabetes with Neurologic or Peripheral Circulatory Manifestation</td>
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<td>32.20 2,506</td>
<td>24.84 2,650</td>
<td>27.91 2,650</td>
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<tr>
<td>HCC17</td>
<td>Diabetes with Acute Complications</td>
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<td>2,242 15.83</td>
<td>2,492 17.57</td>
<td>17.57 2,081</td>
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<tr>
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<td>1,361 12.18</td>
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<tr>
<td>HCC19</td>
<td>Diabetes with No or Unspecified Complications</td>
<td>912 22.79</td>
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<td>Other Endocrine/Metabolic/Nutritional Disorders</td>
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<td>End-Stage Liver Disease</td>
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### Table 4-2 (continued)

Hierarchical Condition Categories Prospective Risk Adjustment Models

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Hierarchical Condition Categories Prospective Risk Adjustment Models

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### Table 4-2 (continued)

#### Hierarchical Condition Categories Prospective Risk Adjustment Models

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<td>8.27</td>
<td>956</td>
<td>8.15</td>
<td>1,047</td>
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<td>HCC156 Concussion or Unspecified Head Injury</td>
<td>38</td>
<td>0.11</td>
<td>41</td>
<td>0.12</td>
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<td>HCC157 Vertebral Fractures</td>
<td>2,017</td>
<td>17.36</td>
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<td>17.50</td>
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<td>HCC158 Hip Fracture/Dislocation</td>
<td>467</td>
<td>5.19</td>
<td>489</td>
<td>5.44</td>
<td>1,031</td>
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<tr>
<td>HCC159 Major Fracture, Except of Skull, Vertebræ, or Hip</td>
<td>740</td>
<td>8.01</td>
<td>741</td>
<td>8.02</td>
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<tr>
<td>HCC160 Internal Injuries</td>
<td>66</td>
<td>0.31</td>
<td>62</td>
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<td>HCC161 Traumatic Amputation</td>
<td>3,463</td>
<td>11.73</td>
<td>3,466</td>
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<td>HCC162 Other Injuries</td>
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<td>HCC163 Poisonings and Allergic Reactions</td>
<td>405</td>
<td>6.64</td>
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<td>HCC164 Major Complications of Medical Care and Trauma</td>
<td>560</td>
<td>7.35</td>
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<td>7.24</td>
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<td>HCC165 Other Complications of Medical Care</td>
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<td>HCC166 Major Symptoms, Abnormalities</td>
<td>569</td>
<td>18.38</td>
<td>564</td>
<td>18.22</td>
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<td>HCC167 Minor Symptoms, Signs, Findings</td>
<td>2</td>
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<td>HCC168 Extremely Low Birthweight Neonates</td>
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<td>5,442</td>
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<td>HCC169 Very Low Birthweight Neonates</td>
<td>-2,732</td>
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<td>606</td>
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<td>HCC172 Normal, Single Birth</td>
<td>2,402</td>
<td>0.87</td>
<td>2,500</td>
<td>0.91</td>
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<td>HCC173 Major Organ Transplant</td>
<td>0</td>
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<td>HCC174 Major Organ Transplant Status</td>
<td>3,717</td>
<td>7.91</td>
<td>3,404</td>
<td>7.23</td>
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<td>HCC175 Other Organ Transplant/Replacement</td>
<td>663</td>
<td>2.82</td>
<td>646</td>
<td>2.79</td>
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<tr>
<td>HCC176 Artificial Openings for Feeding or Elimination</td>
<td>1,996</td>
<td>12.32</td>
<td>1,977</td>
<td>12.20</td>
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<td>HCC177 Amputation Status, Lower Limb/Amputation Complications</td>
<td>3,792</td>
<td>12.60</td>
<td>3,786</td>
<td>12.58</td>
<td>3,768</td>
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<td>HCC178 Amputation Status, Upper Limb</td>
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<tr>
<td>HCC179 Post-Surgical States/Aftercare/Elective</td>
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<td>-0.29</td>
<td>-12</td>
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<td>HCC181 Chemotherapy</td>
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<td>HCC182 Rehabilitation</td>
<td>170</td>
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<td>168</td>
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<td>HCC183 Screening/Observation/Special Exams</td>
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<td>-9.58</td>
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<tr>
<td>HCC184 History of Disease</td>
<td>0</td>
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<td>HCC185 Oxygen</td>
<td>0</td>
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<td>HCC186 CPA/FIPP/Nebulizers</td>
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<td>HCC187 Patient Lifts, Power Operated Vehicles, Beds</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>HCC188 Wheelchairs, Commodores</td>
<td>0</td>
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<td>HCC189 Walkers</td>
<td>0</td>
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Health Economics Research, Inc.
DCG/HCC Models for Medicare Risk Adjustment: 4-31
### Table 4-2 (continued)

#### Hierarchical Condition Categories Prospective Risk Adjustment Models

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<tr>
<th>Variable</th>
<th>Label</th>
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<tr>
<td>D_HCC5</td>
<td>DISABLED*OPPORTUNISTIC INFECTIONS</td>
</tr>
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<td>D_HCC44</td>
<td>DISABLED*SEVERE HEMATOLOGICAL DISORDERS</td>
</tr>
<tr>
<td>D_HCC45</td>
<td>DISABLED*DISORDERS OF IMMUNITY</td>
</tr>
<tr>
<td>D_HCC46</td>
<td>DISABLED*COAGULATION DEFECTS</td>
</tr>
<tr>
<td>D_HCC51</td>
<td>DISABLED*DRUG/ALCOHOL PSYCHOSIS</td>
</tr>
<tr>
<td>D_HCC52</td>
<td>DISABLED*DRUG/ALCOHOL DEPENDENCE</td>
</tr>
<tr>
<td>D_HCC54</td>
<td>DISABLED* SCHIZOPHRENIA</td>
</tr>
<tr>
<td>D_HCC72</td>
<td>DISABLED* MULTIPLE SCLEROSIS</td>
</tr>
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<td>D_HCC107</td>
<td>DISABLED* CYSTIC FIBROSIS</td>
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<table>
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<tr>
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<th>1</th>
<th>2</th>
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<th>4</th>
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<td><strong>Parameter</strong></td>
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<tr>
<td><strong>Estimate</strong></td>
<td><strong>Estimate</strong></td>
<td><strong>Estimate</strong></td>
<td><strong>Estimate</strong></td>
<td><strong>Estimate</strong></td>
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<tr>
<td><strong>t-ratio</strong></td>
<td><strong>t-ratio</strong></td>
<td><strong>t-ratio</strong></td>
<td><strong>t-ratio</strong></td>
<td><strong>t-ratio</strong></td>
<td><strong>t-ratio</strong></td>
</tr>
</tbody>
</table>

- **Exclusions, Excl, Constr, Base Model**
- **All HCCs, Disabled Interactions**
- **Exclusions, Constraints, Disabled Interactions**
- **Excl, Constr, All Dx Interactions**
- **Base Model (Selected DxD Interactions)**

---

**Health Economics Research, Inc.**

DCG/HCC Models for Medicare Risk Adjustment: 4-32
### Table 4-2 (continued)

#### Hierarchical Condition Categories Prospective Risk Adjustment Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>1 (All HCCs)</th>
<th>2 (All HCCs, Disabled Interactions)</th>
<th>3 (Exclusions, Constrains, Disabled Interactions)</th>
<th>4 (Excl, Constr, All Dx Interactions)</th>
<th>5 (Base Model, Selected Dx Interactions)</th>
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<tbody>
<tr>
<td>INT32</td>
<td>CHF *CVD *VD</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>254</td>
<td>1.20</td>
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<tr>
<td>INT33</td>
<td>CHF *CVD *CAD</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>119</td>
<td>0.60</td>
</tr>
<tr>
<td>INT34</td>
<td>CHF *VD *CAD</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>579</td>
<td>3.02</td>
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<tr>
<td>INT35</td>
<td>COPD*CVD *VD</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>-20</td>
<td>-0.09</td>
</tr>
<tr>
<td>INT36</td>
<td>COPD*VD *CAD</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>284</td>
<td>1.45</td>
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<tr>
<td>INT37</td>
<td>CVD *VD *CAD</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>193</td>
<td>1.04</td>
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<tr>
<td>INT38</td>
<td>RF*DM</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>-156</td>
<td>-0.53</td>
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</tbody>
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**NOTES:**

- Diagnoses assigned using Source=1-5.
- Coefficients of HCCs 161 and 177 are constrained to be equal in Model 3, 4, and 5.
- "|" means coefficients of HCCs are constrained to be equal in Model 3, 4, and 5.
- DM= diabetes mellitus (HCCs 15-20)
- CHF= congestive heart failure (HCC 80)
- COPD= chronic obstructive pulmonary disease (HCC 108)
- CVD= cerebrovascular disease (HCCs 95-103)
- VD= vascular disease (HCCs 104-105)
- CAD= coronary artery disease (HCCs 81-84)
- RF= renal failure (HCC 131)

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
Table 4-3
HCC Parameter Difference by Aged Versus Disabled

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>Disabled Parameter Estimate</th>
<th>Aged Parameter Estimate</th>
<th>Coefficient Difference (Disabled-Aged)</th>
<th>t Statistic for Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCC1</td>
<td>HIV/AIDS</td>
<td>3,196</td>
<td>-380</td>
<td>3,576</td>
<td>4.22</td>
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<tr>
<td>HCC2</td>
<td>Septicemia/Shock</td>
<td>2,256</td>
<td>3,088</td>
<td>-831</td>
<td>-2.23</td>
</tr>
<tr>
<td>HCC3</td>
<td>Central Nervous System Infection</td>
<td>799</td>
<td>862</td>
<td>-64</td>
<td>-0.13</td>
</tr>
<tr>
<td>HCC4</td>
<td>Tuberculosis</td>
<td>1,438</td>
<td>403</td>
<td>1,035</td>
<td>1.81</td>
</tr>
<tr>
<td>HCC5</td>
<td>Opportunistic Infections</td>
<td>6,489</td>
<td>4,047</td>
<td>2,441</td>
<td>3.58</td>
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<tr>
<td>HCC6</td>
<td>Other Infectious Diseases</td>
<td>383</td>
<td>331</td>
<td>52</td>
<td>0.49</td>
</tr>
<tr>
<td>HCC7</td>
<td>Metastatic Cancer and Acute Leukemia</td>
<td>8,200</td>
<td>6,506</td>
<td>1,694</td>
<td>3.73</td>
</tr>
<tr>
<td>HCC8</td>
<td>Lung, Upper Digestive Tract, and Other Severe Cancers</td>
<td>2,750</td>
<td>3,809</td>
<td>-1,059</td>
<td>-2.27</td>
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<td>HCC9</td>
<td>Lymphatic, Head and Neck, Brain, and Other Major Cancers</td>
<td>2,041</td>
<td>2,108</td>
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<tr>
<td>HCC10</td>
<td>Breast, Prostate, Colorectal and Other Cancers and Tumors</td>
<td>106</td>
<td>699</td>
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<tr>
<td>HCC11</td>
<td>Other Respiratory and Heart Neoplasms</td>
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<td>510</td>
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<td>HCC12</td>
<td>Other Digestive and Urinary Neoplasms</td>
<td>-292</td>
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<td>HCC13</td>
<td>Other Neoplasms</td>
<td>-92</td>
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<td>HCC14</td>
<td>Benign Neoplasms of Skin, Breast, Eye</td>
<td>-555</td>
<td>-266</td>
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<tr>
<td>HCC15</td>
<td>Diabetes with Renal Manifestation</td>
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<tr>
<td>HCC16</td>
<td>Diabetes with Neurologic or Peripheral Circulatory Manifestation</td>
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<td>HCC17</td>
<td>Diabetes with Acute Complications</td>
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<tr>
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<td>Diabetes with Ophthalmologic Manifestation</td>
<td>-327</td>
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<td>Diabetes with No or Unspecified Complications</td>
<td>482</td>
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<td>Type I Diabetes Mellitus</td>
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<td>Protein-Calorie Malnutrition</td>
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<td>Other Significant Endocrine and Metabolic Disorders</td>
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<td>Disorders of Fluid/Electrolyte/Acid-Base Balance</td>
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<td>952</td>
<td>1,104</td>
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<td>HCC25</td>
<td>End-Stage Liver Disease</td>
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<td>HCC26</td>
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<td>Chronic Hepatitis</td>
<td>1,682</td>
<td>1,762</td>
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</table>
### Table 4-3 (continued)

#### HCC Parameter Difference by Aged Versus Disabled

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>Disabled Parameter Estimate</th>
<th>Aged Parameter Estimate</th>
<th>Coefficient Difference (Disabled-Aged)</th>
<th>t Statistic for Difference</th>
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<td>HCC28</td>
<td>Acute Liver Failure/Disease</td>
<td>841</td>
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<td>Other Hepatitis and Liver Disease</td>
<td>1,182</td>
<td>572</td>
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<td>HCC30</td>
<td>Gallbladder and Biliary Tract Disorders</td>
<td>609</td>
<td>-306</td>
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<td>HCC31</td>
<td>Intestinal Obstruction/Perforation</td>
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<td>HCC32</td>
<td>Pancreatic Disease</td>
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<td>Inflammatory Bowel Disease</td>
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<td>Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders</td>
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<td>Appendicitis</td>
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<td>Other Gastrointestinal Disorders</td>
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<td>Bone/Joint/Muscle Infections/Necrosis</td>
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<td>Rheumatoid Arthritis and Inflammatory Connective Tissue Disease</td>
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<td>Disorders of the Verterbrae and Spinal Discs</td>
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<td>Osteoarthritis of Hip or Knee</td>
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<td>Osteoporosis and Other Bone/Cartilage Disorders</td>
<td>1,355</td>
<td>551</td>
<td>804</td>
<td>4.48</td>
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<tr>
<td>HCC42</td>
<td>Congenital/Developmental Skeletal and Connective Tissue Disorders</td>
<td>329</td>
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<td>4,722</td>
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<td>586</td>
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Health Economics Research, Inc.  
DCG/HCC Models for Medicare Risk Adjustment: 4-35
### Table 4-3 (continued)

**HCC Parameter Difference by Aged Versus Disabled**

<table>
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<tr>
<th>Variable</th>
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<th>Disabled Parameter Estimate</th>
<th>Aged Parameter Estimate</th>
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Table 4-3 (continued)

HCC Parameter Difference by Aged Versus Disabled

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<th>Label</th>
<th>Disabled Parameter Estimate</th>
<th>Aged Parameter Estimate</th>
<th>Coefficient Difference (Disabled-Aged)</th>
<th>t Statistic for Difference</th>
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<td>Other Congenital Heart/Circulatory Disease</td>
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<tr>
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</table>
Table 4-3 (continued)

HCC Parameter Difference by Aged Versus Disabled

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<th>Label</th>
<th>Disabled Parameter Estimate</th>
<th>Aged Parameter Estimate</th>
<th>Coefficient Difference (Disabled-Aged)</th>
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<td>Aged Parameter Estimate</td>
<td>Coefficient Difference (Disabled-Aged)</td>
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<td>Male Genital Disorders</td>
<td>-28</td>
<td>-302</td>
<td>274</td>
<td>1.73</td>
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<tr>
<td>HCC141</td>
<td>Ectopic Pregnancy</td>
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<tr>
<td>HCC142</td>
<td>Miscarriage/Abortion</td>
<td>-1,236</td>
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</tr>
<tr>
<td>HCC143</td>
<td>Completed Pregnancy With Major Complications</td>
<td>-764</td>
<td>--</td>
<td>--</td>
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</tr>
<tr>
<td>HCC144</td>
<td>Completed Pregnancy With Complications</td>
<td>917</td>
<td>--</td>
<td>--</td>
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</tr>
<tr>
<td>HCC145</td>
<td>Completed Pregnancy Without Complications</td>
<td>157</td>
<td>--</td>
<td>--</td>
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</tr>
<tr>
<td></td>
<td>(Normal Delivery)</td>
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<tr>
<td>HCC146</td>
<td>Uncompleted Pregnancy With Complications</td>
<td>2,466</td>
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<tr>
<td>HCC147</td>
<td>Uncompleted Pregnancy With No or Minor Complications</td>
<td>675</td>
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<td>--</td>
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<td>HCC148</td>
<td>Decubitus Ulcer of Skin</td>
<td>6,909</td>
<td>3,486</td>
<td>3,423</td>
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<td>HCC149</td>
<td>Chronic Ulcer of Skin, Except Decubitus</td>
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<tr>
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<td>Extensive Third-Degree Burns</td>
<td>7,511</td>
<td>5,269</td>
<td>2,242</td>
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<tr>
<td>HCC151</td>
<td>Other Third-Degree and Extensive Burns</td>
<td>3,399</td>
<td>1,289</td>
<td>2,110</td>
<td>1.62</td>
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<tr>
<td>HCC152</td>
<td>Cellulitis, Local Skin Infection</td>
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<td>602</td>
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<td>HCC153</td>
<td>Other Dermatological Disorders</td>
<td>52</td>
<td>94</td>
<td>-42</td>
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<tr>
<td>HCC154</td>
<td>Severe Head Injury</td>
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<td>5,544</td>
<td>-4,096</td>
<td>-2.05</td>
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<tr>
<td>HCC155</td>
<td>Major Head Injury</td>
<td>1,279</td>
<td>862</td>
<td>417</td>
<td>1.39</td>
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<tr>
<td>HCC156</td>
<td>Concussion or Unspecified Head Injury</td>
<td>-272</td>
<td>73</td>
<td>-345</td>
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<tr>
<td>HCC157</td>
<td>Vertebral Fractures</td>
<td>1,736</td>
<td>2,096</td>
<td>-360</td>
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## Table 4-3 (continued)

**HCC Parameter Difference by Aged Versus Disabled**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>Disabled Parameter Estimate</th>
<th>Aged Parameter Estimate</th>
<th>Coefficient Difference (Disabled-Aged)</th>
<th>t Statistic for Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCC158</td>
<td>Hip Fracture/Dislocation</td>
<td>1,233</td>
<td>518</td>
<td>715</td>
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</tr>
<tr>
<td>HCC159</td>
<td>Major Fracture, Except of Skull, Vertebrae, or Hip</td>
<td>869</td>
<td>704</td>
<td>165</td>
<td>0.57</td>
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<tr>
<td>HCC160</td>
<td>Internal Injuries</td>
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<td>HCC161</td>
<td>Traumatic Amputation</td>
<td>4,439</td>
<td>3,184</td>
<td>1,254</td>
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<tr>
<td>HCC162</td>
<td>Other Injuries</td>
<td>334</td>
<td>471</td>
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<tr>
<td>HCC163</td>
<td>Poisonings and Allegic Reactions</td>
<td>661</td>
<td>324</td>
<td>337</td>
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</tr>
<tr>
<td>HCC164</td>
<td>Major Complications of Medical Care and Trauma</td>
<td>1,776</td>
<td>360</td>
<td>1,416</td>
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<tr>
<td>HCC165</td>
<td>Other Complications of Medical Care</td>
<td>629</td>
<td>-156</td>
<td>784</td>
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<tr>
<td>HCC166</td>
<td>Major Symptoms, Abnormalities</td>
<td>470</td>
<td>571</td>
<td>-101</td>
<td>-1.05</td>
</tr>
<tr>
<td>HCC167</td>
<td>Minor Symptoms, Signs, Findings</td>
<td>-237</td>
<td>25</td>
<td>-262</td>
<td>-2.46</td>
</tr>
<tr>
<td>HCC168</td>
<td>Extremely Low Birthweight Neonates</td>
<td>-3,214</td>
<td>10,267</td>
<td>-13,481</td>
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</tr>
<tr>
<td>HCC169</td>
<td>Very Low Birthweight Neonates</td>
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<td>-2,608</td>
<td>2,608</td>
<td>0.35</td>
</tr>
<tr>
<td>HCC170</td>
<td>Serious Perinatal Problem Affecting Newborn</td>
<td>373</td>
<td>2,032</td>
<td>-1,660</td>
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</tr>
<tr>
<td>HCC171</td>
<td>Other Perinatal Problems Affecting Newborn</td>
<td>150</td>
<td>695</td>
<td>-545</td>
<td>-0.63</td>
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<tr>
<td>HCC172</td>
<td>Normal, Single Birth</td>
<td>5,472</td>
<td>1,405</td>
<td>4,067</td>
<td>6.66</td>
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<tr>
<td>HCC173</td>
<td>Major Organ Transplant</td>
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<td>n/a</td>
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<tr>
<td>HCC174</td>
<td>Major Organ Transplant Status</td>
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<td>2,869</td>
<td>173</td>
<td>0.18</td>
</tr>
<tr>
<td>HCC175</td>
<td>Other Organ Transplant/Replacement</td>
<td>2,340</td>
<td>487</td>
<td>1,852</td>
<td>2.23</td>
</tr>
<tr>
<td>HCC176</td>
<td>Artificial Openings for Feeding or Elimination</td>
<td>2,567</td>
<td>1,759</td>
<td>808</td>
<td>1.75</td>
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<tr>
<td>HCC177</td>
<td>Amputation Status, Lower Limb/Amputation Complications</td>
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<td>3,661</td>
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<tr>
<td>HCC178</td>
<td>Amputation Status, Upper Limb</td>
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<td>709</td>
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<tr>
<td>HCC179</td>
<td>Post-Surgical States/Aftercare/Elective</td>
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<td>-41</td>
<td>430</td>
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<tr>
<td>HCC180</td>
<td>Radiation Therapy</td>
<td>1,569</td>
<td>1,582</td>
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<td>HCC181</td>
<td>Chemotherapy</td>
<td>4,753</td>
<td>5,540</td>
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<tr>
<td>HCC182</td>
<td>Rehabilitation</td>
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<td>1,257</td>
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<tr>
<td>HCC183</td>
<td>Screening/Observation/Special Exams</td>
<td>-186</td>
<td>-268</td>
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<td>1.04</td>
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<tr>
<td>HCC184</td>
<td>History of Disease</td>
<td>586</td>
<td>-50</td>
<td>636</td>
<td>4.25</td>
</tr>
<tr>
<td>HCC185</td>
<td>Oxygen</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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</table>
### Table 4-3 (continued)

HCC Parameter Difference by Aged Versus Disabled

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>Disabled Parameter Estimate</th>
<th>Aged Parameter Estimate</th>
<th>Coefficient Difference (Disabled-Aged)</th>
<th>t Statistic for Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCC186</td>
<td>CPAP/IPPB/Nebulizers</td>
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<tr>
<td>HCC187</td>
<td>Patient Lifts, Power Operated Vehicles, Beds</td>
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<td>n/a</td>
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<tr>
<td>HCC188</td>
<td>Wheelchairs, Commodes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>HCC189</td>
<td>Walkers</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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**OUTPUT:** D9pr14.ou2

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
Table 4-3a

Frequency of HCCs by Aged Versus Disabled

<table>
<thead>
<tr>
<th>HCC</th>
<th>Label</th>
<th>Aged</th>
<th>Disabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HIV/AIDS</td>
<td>319</td>
<td>1,447</td>
</tr>
<tr>
<td>2</td>
<td>Septicemia/Shock</td>
<td>14,559</td>
<td>1,762</td>
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<tr>
<td>3</td>
<td>Central Nervous System Infection</td>
<td>3,869</td>
<td>961</td>
</tr>
<tr>
<td>4</td>
<td>Tuberculosis</td>
<td>2,663</td>
<td>656</td>
</tr>
<tr>
<td>5</td>
<td>Opportunistic Infections</td>
<td>1,700</td>
<td>575</td>
</tr>
<tr>
<td>6</td>
<td>Other Infectious Diseases</td>
<td>199,209</td>
<td>21,861</td>
</tr>
<tr>
<td>7</td>
<td>Metastatic Cancer and Acute Leukemia</td>
<td>16,265</td>
<td>1,114</td>
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<tr>
<td>8</td>
<td>Lung, Upper Digestive Tract, and Other Severe Cancers</td>
<td>11,603</td>
<td>908</td>
</tr>
<tr>
<td>9</td>
<td>Lymphatic, Head and Neck, Brain, and Other Major Cancers</td>
<td>16,619</td>
<td>1,685</td>
</tr>
<tr>
<td>10</td>
<td>Breast, Prostate, Colorectal and Other Cancers and Tumors</td>
<td>92,317</td>
<td>3,685</td>
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<tr>
<td>11</td>
<td>Other Respiratory and Heart Neoplasms</td>
<td>2,979</td>
<td>331</td>
</tr>
<tr>
<td>12</td>
<td>Other Digestive and Urinary Neoplasms</td>
<td>35,996</td>
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<tr>
<td>13</td>
<td>Other Neoplasms</td>
<td>74,708</td>
<td>5,197</td>
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<tr>
<td>14</td>
<td>Benign Neoplasms of Skin, Breast, Eye</td>
<td>112,246</td>
<td>9,993</td>
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<tr>
<td>15</td>
<td>Diabetes with Renal Manifestation</td>
<td>4,497</td>
<td>1,108</td>
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<tr>
<td>16</td>
<td>Diabetes with Neurologic or Peripheral Circulatory Manifesta</td>
<td>26,191</td>
<td>3,030</td>
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<td>17</td>
<td>Diabetes with Acute Complications</td>
<td>8,575</td>
<td>1,463</td>
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<tr>
<td>18</td>
<td>Diabetes with Ophthalmologic Manifestation</td>
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<td>19</td>
<td>Diabetes with No or Unspecified Complications</td>
<td>133,775</td>
<td>15,211</td>
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<td>20</td>
<td>Type I Diabetes Mellitus</td>
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<td>21</td>
<td>Protein-Calorie Malnutrition</td>
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<td>22</td>
<td>Other Significant Endocrine and Metabolic Disorders</td>
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<tr>
<td>23</td>
<td>Disorders of Fluid/Electrolyte/Acid-Base Balance</td>
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<td>9,507</td>
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<td>24</td>
<td>Other Endocrine/Metabolic/Nutritional Disorders</td>
<td>311,103</td>
<td>29,185</td>
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<tr>
<td>25</td>
<td>End-Stage Liver Disease</td>
<td>1,725</td>
<td>507</td>
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<tr>
<td>26</td>
<td>Cirrhosis of Liver</td>
<td>3,165</td>
<td>1,066</td>
</tr>
<tr>
<td>27</td>
<td>Chronic Hepatitis</td>
<td>959</td>
<td>553</td>
</tr>
<tr>
<td>28</td>
<td>Acute Liver Failure/Disease</td>
<td>852</td>
<td>392</td>
</tr>
</tbody>
</table>

Health Economics Research, Inc.  DCG/HCC Models for Medicare Risk Adjustment: 4-42
Table 4-3a (continued)

Frequency of HCCs by Aged Versus Disabled

<table>
<thead>
<tr>
<th>HCC</th>
<th>Label</th>
<th>Aged Frequency</th>
<th>Aged Person Years</th>
<th>Disabled Frequency</th>
<th>Disabled Person Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>Other Hepatitis and Liver Disease</td>
<td>10,966</td>
<td>10,169</td>
<td>2,302</td>
<td>2,212</td>
</tr>
<tr>
<td>30</td>
<td>Gallbladder and Biliary Tract Disorders</td>
<td>19,218</td>
<td>18,008</td>
<td>2,510</td>
<td>2,407</td>
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<tr>
<td>31</td>
<td>Intestinal Obstruction/Perforation</td>
<td>24,791</td>
<td>22,373</td>
<td>2,736</td>
<td>2,597</td>
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<tr>
<td>32</td>
<td>Pancreatic Disease</td>
<td>8,503</td>
<td>7,846</td>
<td>1,740</td>
<td>1,643</td>
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<tr>
<td>33</td>
<td>Inflammatory Bowel Disease</td>
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<td>1,027</td>
<td>1,000</td>
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<td>Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal D</td>
<td>74,099</td>
<td>69,542</td>
<td>8,456</td>
<td>8,173</td>
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<td>Appendicitis</td>
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<td>36</td>
<td>Other Gastrointestinal Disorders</td>
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<td>234,542</td>
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<td>Bone/Joint/Muscle Infections/Necrosis</td>
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<td>38</td>
<td>Rheumatoid Arthritis and Inflammatory Connective Tissue Dise</td>
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<td>Disorders of the Vertebræ and Spinal Discs</td>
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<td>Osteoarthritis of Hip or Knee</td>
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<td>41</td>
<td>Osteoporosis and Other Bone/Cartilage Disorders</td>
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<td>83,440</td>
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<td>42</td>
<td>Congenital/Developmental Skeletal and Connective Tissue Diso</td>
<td>916</td>
<td>874</td>
<td>251</td>
<td>248</td>
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<tr>
<td>43</td>
<td>Other Musculoskeletal and Connective Tissue Disorders</td>
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<td>322,165</td>
<td>38,666</td>
<td>37,696</td>
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<tr>
<td>44</td>
<td>Severe Hematological Disorders</td>
<td>6,857</td>
<td>5,885</td>
<td>883</td>
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<td>45</td>
<td>Disorders of Immunity</td>
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<td>5,638</td>
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<td>1,267</td>
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<tr>
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<td>Coagulation Defects and Other Specified Hematological Disor</td>
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<td>28,135</td>
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<td>Iron Deficiency and Other/Unspecified Anemias and Blood Dise</td>
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<td>111,066</td>
<td>10,221</td>
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<tr>
<td>48</td>
<td>Delirium and Encephalopathy</td>
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<td>49</td>
<td>Dementia</td>
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<td>63,287</td>
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<tr>
<td>50</td>
<td>Senility, Nonpsychotic Organic Brain Syndromes/Conditions</td>
<td>9,078</td>
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<td>1,598</td>
<td>1,554</td>
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<td>51</td>
<td>Drug/Alcohol Psychosis</td>
<td>3,470</td>
<td>3,160</td>
<td>1,820</td>
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<td>52</td>
<td>Drug/Alcohol Dependence</td>
<td>4,012</td>
<td>3,672</td>
<td>4,793</td>
<td>4,638</td>
</tr>
<tr>
<td>53</td>
<td>Drug/Alcohol Abuse, Without Dependence</td>
<td>13,560</td>
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<td>54</td>
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<td>15,046</td>
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<tr>
<td>55</td>
<td>Major Depressive, Bipolar, and Paranoid Disorders</td>
<td>26,396</td>
<td>24,664</td>
<td>12,725</td>
<td>12,432</td>
</tr>
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Table 4-3a (continued)

Frequency of HCCs by Aged Versus Disabled

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Table 4-3a (continued)

Frequency of HCCs by Aged Versus Disabled

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### Table 4-3a (continued)

Frequency of HCCs by Aged Versus Disabled

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<th>Aged Person Years</th>
<th>Disabled Frequency</th>
<th>Disabled Person Years</th>
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Table 4-3a (continued)

Frequency of HCCs by Aged Versus Disabled

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<th>Label</th>
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<th>Aged Person Years</th>
<th>Disabled Frequency</th>
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<td>159</td>
<td>Major Fracture, Except of Skull, Vertebrae, or Hip</td>
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<tr>
<td>160</td>
<td>Internal Injuries</td>
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<td>161</td>
<td>Traumatic Amputation</td>
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<td>162</td>
<td>Other Injuries</td>
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<tr>
<td>163</td>
<td>Poisonings and Allegic Reactions</td>
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<tr>
<td>164</td>
<td>Major Complications of Medical Care and Trauma</td>
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<tr>
<td>165</td>
<td>Other Complications of Medical Care</td>
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<tr>
<td>166</td>
<td>Major Symptoms, Abnormalities</td>
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<tr>
<td>167</td>
<td>Minor Symptoms, Signs, Findings</td>
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<tr>
<td>168</td>
<td>Extremely Low Birthweight Neonates</td>
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</table>

DCG/HCC Models for Medicare Risk Adjustment: 4-47
Table 4-3a (continued)

Frequency of HCCs by Aged Versus Disabled

<table>
<thead>
<tr>
<th>HCC</th>
<th>Label</th>
<th>Aged Frequency</th>
<th>Aged Person Years</th>
<th>Disabled Frequency</th>
<th>Disabled Person Years</th>
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<td>169</td>
<td>Very Low Birthweight Neonates</td>
<td>3</td>
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<td>284</td>
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<tr>
<td>170</td>
<td>Serious Perinatal Problem Affecting Newborn</td>
<td>1,977</td>
<td>1,820</td>
<td>262</td>
<td>257</td>
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<tr>
<td>171</td>
<td>Other Perinatal Problems Affecting Newborn</td>
<td>1,656</td>
<td>1,536</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>172</td>
<td>Normal, Single Birth</td>
<td>17</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>174</td>
<td>Major Organ Transplant Status</td>
<td>357</td>
<td>336</td>
<td>481</td>
<td>444</td>
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<tr>
<td>175</td>
<td>Other Organ Transplant/Replacement</td>
<td>2,985</td>
<td>2,842</td>
<td>268</td>
<td>259</td>
</tr>
<tr>
<td>176</td>
<td>Artificial Openings for Feeding or Elimination</td>
<td>6,928</td>
<td>5,951</td>
<td>1,080</td>
<td>1,007</td>
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<tr>
<td>177</td>
<td>Amputation Status, Lower Limb/Amputation Complications</td>
<td>1,656</td>
<td>1,453</td>
<td>494</td>
<td>464</td>
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<tr>
<td>178</td>
<td>Amputation Status, Upper Limb</td>
<td>128</td>
<td>118</td>
<td>36</td>
<td>34</td>
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<tr>
<td>179</td>
<td>Post-Surgical States/Aftercare/Elective</td>
<td>184,340</td>
<td>175,126</td>
<td>12,768</td>
<td>12,304</td>
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<tr>
<td>180</td>
<td>Radiation Therapy</td>
<td>5,485</td>
<td>4,822</td>
<td>271</td>
<td>235</td>
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<tr>
<td>181</td>
<td>Chemotherapy</td>
<td>6,001</td>
<td>4,985</td>
<td>512</td>
<td>430</td>
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<tr>
<td>182</td>
<td>Rehabilitation</td>
<td>27,363</td>
<td>25,859</td>
<td>3,295</td>
<td>3,192</td>
</tr>
<tr>
<td>183</td>
<td>Screening/Observation/Special Exams</td>
<td>747,450</td>
<td>716,051</td>
<td>69,340</td>
<td>67,466</td>
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<tr>
<td>184</td>
<td>History of Disease</td>
<td>127,578</td>
<td>120,769</td>
<td>9,963</td>
<td>9,528</td>
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<td>185</td>
<td>Oxygen</td>
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<td>186</td>
<td>CPAP/IPPB/Nebulizers</td>
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<td></td>
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<tr>
<td>187</td>
<td>Patient Lifts, Power Operated Vehicles, Beds</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>188</td>
<td>Wheelchairs, Commodes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>189</td>
<td>Walkers</td>
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<td></td>
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</table>

OUTPUT: D9PR14AB.out.

<table>
<thead>
<tr>
<th>HCC</th>
<th>Incremental Payments</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elderly</td>
<td>Disabled</td>
<td></td>
</tr>
<tr>
<td>Opportunistic Infections (e.g., AIDS-, cancer-related)</td>
<td>$4,122</td>
<td>$8,013</td>
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</tr>
<tr>
<td>Severe Hematological Disorders (e.g., hemophilia, sickle cell anemia)</td>
<td>$4,930</td>
<td>$9,690</td>
<td></td>
</tr>
<tr>
<td>Disorders of Immunity</td>
<td>$3,603</td>
<td>$4,706</td>
<td></td>
</tr>
<tr>
<td>Coagulation Defects and Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hematological Disorders</td>
<td>$763</td>
<td>$2,762</td>
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</tr>
<tr>
<td>Drug/Alcohol Psychoses</td>
<td>$1,183</td>
<td>$5,193</td>
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<tr>
<td>Drug/Alcohol Dependence</td>
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<td>$3,356</td>
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</tr>
<tr>
<td>Schizophrenia</td>
<td>$2,239</td>
<td>$3,132</td>
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<tr>
<td>Multiple Sclerosis</td>
<td>$2,127</td>
<td>$4,212</td>
<td></td>
</tr>
<tr>
<td>Cystic Fibrosis</td>
<td>$1,826</td>
<td>$8,014</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** From Table 4-2.

**SOURCE:** Health Economics Research, Inc.
### Table 4-5

**Descriptive Statistics for Beneficiaries with Selected Multiple Diagnoses**

<table>
<thead>
<tr>
<th>Diagnosis Combination</th>
<th>Frequency</th>
<th>Person Years</th>
<th>1997 Mean of the Mean</th>
<th>Std. Error of the Mean</th>
<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM *CHF</td>
<td>47,995</td>
<td>43,113</td>
<td>$15,962</td>
<td>$127</td>
<td>$26,402</td>
<td>165%</td>
</tr>
<tr>
<td>DM *COPD</td>
<td>33,786</td>
<td>30,938</td>
<td>14,745</td>
<td>144</td>
<td>25,345</td>
<td>172</td>
</tr>
<tr>
<td>DM *CVD</td>
<td>37,883</td>
<td>34,693</td>
<td>14,214</td>
<td>131</td>
<td>24,383</td>
<td>172</td>
</tr>
<tr>
<td>DM *VD</td>
<td>42,233</td>
<td>38,632</td>
<td>14,726</td>
<td>129</td>
<td>25,403</td>
<td>172</td>
</tr>
<tr>
<td>DM *CAD</td>
<td>77,314</td>
<td>71,867</td>
<td>12,398</td>
<td>85</td>
<td>22,692</td>
<td>183</td>
</tr>
<tr>
<td>CHF *COPD</td>
<td>53,053</td>
<td>47,024</td>
<td>16,253</td>
<td>143</td>
<td>25,337</td>
<td>164</td>
</tr>
<tr>
<td>CHF *CVD</td>
<td>39,744</td>
<td>35,077</td>
<td>16,014</td>
<td>141</td>
<td>25,383</td>
<td>164</td>
</tr>
<tr>
<td>CHF *VD</td>
<td>45,294</td>
<td>39,721</td>
<td>16,734</td>
<td>140</td>
<td>27,936</td>
<td>175</td>
</tr>
<tr>
<td>CHF *CAD</td>
<td>95,980</td>
<td>86,729</td>
<td>13,911</td>
<td>83</td>
<td>24,368</td>
<td>175</td>
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<td>32,038</td>
<td>28,820</td>
<td>15,120</td>
<td>150</td>
<td>25,387</td>
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<td>35,018</td>
<td>15,273</td>
<td>143</td>
<td>26,729</td>
<td>175</td>
</tr>
<tr>
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<td>63,950</td>
<td>13,446</td>
<td>96</td>
<td>24,175</td>
<td>180</td>
</tr>
<tr>
<td>CVD *VD</td>
<td>46,494</td>
<td>42,246</td>
<td>13,541</td>
<td>117</td>
<td>24,175</td>
<td>180</td>
</tr>
<tr>
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<td>67,768</td>
<td>62,311</td>
<td>12,734</td>
<td>91</td>
<td>22,786</td>
<td>179</td>
</tr>
<tr>
<td>VD *CAD</td>
<td>72,150</td>
<td>66,036</td>
<td>13,414</td>
<td>95</td>
<td>24,294</td>
<td>181</td>
</tr>
<tr>
<td>DM *CHF *COPD</td>
<td>15,204</td>
<td>13,366</td>
<td>20,322</td>
<td>262</td>
<td>30,266</td>
<td>149</td>
</tr>
<tr>
<td>DM *CHF *CVD</td>
<td>13,554</td>
<td>11,885</td>
<td>19,668</td>
<td>272</td>
<td>29,626</td>
<td>151</td>
</tr>
<tr>
<td>DM *CHF *VD</td>
<td>15,683</td>
<td>13,621</td>
<td>20,783</td>
<td>269</td>
<td>31,350</td>
<td>151</td>
</tr>
<tr>
<td>DM *CHF *CAD</td>
<td>31,655</td>
<td>28,263</td>
<td>17,409</td>
<td>164</td>
<td>27,631</td>
<td>159</td>
</tr>
<tr>
<td>DM <em>COPD</em>CVD</td>
<td>8,402</td>
<td>7,461</td>
<td>19,675</td>
<td>336</td>
<td>29,042</td>
<td>148</td>
</tr>
<tr>
<td>DM <em>COPD</em>VD</td>
<td>10,349</td>
<td>9,195</td>
<td>20,031</td>
<td>317</td>
<td>30,397</td>
<td>152</td>
</tr>
<tr>
<td>DM <em>COPD</em>CAD</td>
<td>18,244</td>
<td>16,460</td>
<td>17,652</td>
<td>214</td>
<td>27,453</td>
<td>156</td>
</tr>
<tr>
<td>DM *CVD *VD</td>
<td>13,965</td>
<td>12,541</td>
<td>17,619</td>
<td>251</td>
<td>28,103</td>
<td>160</td>
</tr>
<tr>
<td>DM *CVD *CAD</td>
<td>20,513</td>
<td>18,616</td>
<td>16,528</td>
<td>195</td>
<td>26,617</td>
<td>161</td>
</tr>
<tr>
<td>DM *VD *CAD</td>
<td>22,906</td>
<td>20,715</td>
<td>17,341</td>
<td>195</td>
<td>28,064</td>
<td>162</td>
</tr>
<tr>
<td>CHF <em>COPD</em>CVD</td>
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<td>11,776</td>
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<td>17,796</td>
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<td>28,246</td>
<td>159</td>
</tr>
<tr>
<td>CHF *CVD *VD</td>
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<td>13,942</td>
<td>19,049</td>
<td>254</td>
<td>30,050</td>
<td>158</td>
</tr>
<tr>
<td>CHF *CVD *CAD</td>
<td>27,133</td>
<td>23,924</td>
<td>17,212</td>
<td>178</td>
<td>27,550</td>
<td>160</td>
</tr>
<tr>
<td>CHF *VD *CAD</td>
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<td>27,217</td>
<td>17,960</td>
<td>177</td>
<td>29,243</td>
<td>163</td>
</tr>
<tr>
<td>COPD*CVD *VD</td>
<td>13,104</td>
<td>11,551</td>
<td>17,933</td>
<td>267</td>
<td>28,642</td>
<td>160</td>
</tr>
<tr>
<td>COPD*CVD *CAD</td>
<td>18,783</td>
<td>16,752</td>
<td>17,348</td>
<td>212</td>
<td>27,449</td>
<td>158</td>
</tr>
<tr>
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<td>17,523</td>
<td>205</td>
<td>29,059</td>
<td>166</td>
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<tr>
<td>CVD *VD *CAD</td>
<td>26,169</td>
<td>23,644</td>
<td>15,596</td>
<td>171</td>
<td>26,247</td>
<td>168</td>
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<td>RF*CHF</td>
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<td>21,853</td>
<td>390</td>
<td>37,839</td>
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<tr>
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<td>7,092</td>
<td>20,891</td>
<td>421</td>
<td>35,413</td>
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<tr>
<td>RF<em>CHF</em>DM</td>
<td>5,210</td>
<td>4,159</td>
<td>25,770</td>
<td>622</td>
<td>40,141</td>
<td>156</td>
</tr>
</tbody>
</table>

1 Expenditures are annualized and weighted by the fraction of the year eligible.

**NOTES**

DM= diabetes mellitus  
CHF= congestive heart failure  
COPD= chronic obstructive pulmonary disease  
CVD= cerebrovascular disease  
VD= vascular disease  
CAD= coronary artery disease  
RF= renal failure  
Diagnoses assigned using Source=1-5.

**OUTPUT**: D9pr03h.cor and D9pr03h.out

**SOURCE**: Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
### Table 4-6

Interactions Among Diagnoses: Interactions Included in Base Model

<table>
<thead>
<tr>
<th>Diagnoses</th>
<th>Incremental Payment</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dx Sum(^1)</td>
<td>Dx Interaction(^2)</td>
<td>Total</td>
</tr>
<tr>
<td>Diabetes+CHF</td>
<td>$4,474</td>
<td>$1,036</td>
<td>$5,510</td>
</tr>
<tr>
<td>Diabetes+CVD</td>
<td>3,355</td>
<td>559</td>
<td>3,914</td>
</tr>
<tr>
<td>CHF+COPD</td>
<td>3,650</td>
<td>1,590</td>
<td>5,240</td>
</tr>
<tr>
<td>COPD+CVD+CAD</td>
<td>3,460</td>
<td>521</td>
<td>3,981</td>
</tr>
<tr>
<td>CHF+Renal Failure</td>
<td>4,311</td>
<td>1,435</td>
<td>5,746</td>
</tr>
<tr>
<td>Diabetes+CHF+Renal Failure(^3)</td>
<td>8,094</td>
<td>4,151</td>
<td>12,245</td>
</tr>
</tbody>
</table>

**NOTES:**
- CHF=congestive heart failure, CVD=cerebrovascular disease, COPD=chronic obstructive pulmonary disease, CAD=coronary artery disease.
- From Table 4-2.
- \(^1\) Sum of individual effects of diagnoses. For the first two rows, diabetes is assumed to be “diabetes with circulatory manifestation”, and for the last row diabetes is assumed to be “diabetes with renal manifestation”.
- \(^2\) Interactive effect of diagnoses.
- \(^3\) Includes interactive effects of rows 1 and 5 as well as the three-way interactive effect.

**SOURCE:** Health Economics Research, Inc.
### Table 4-7

**Frequencies and Mean Expenditures by Validation Group**

<table>
<thead>
<tr>
<th>Group Label</th>
<th>Frequency</th>
<th>Person Years</th>
<th>1997 Mean Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL ENROLLEES</td>
<td>1,394,701</td>
<td>1,338,647</td>
<td>$5,314</td>
</tr>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>AGED</td>
<td>1,238,205</td>
<td>1,181,767</td>
<td>5,413</td>
</tr>
<tr>
<td>DISABLED</td>
<td>162,629</td>
<td>154,665</td>
<td>4,559</td>
</tr>
<tr>
<td>FEMALE, &lt;=34</td>
<td>7,622</td>
<td>6,919</td>
<td>3,650</td>
</tr>
<tr>
<td>FEMALE, 35-44</td>
<td>15,162</td>
<td>13,330</td>
<td>4,236</td>
</tr>
<tr>
<td>FEMALE, 45-54</td>
<td>20,316</td>
<td>17,554</td>
<td>4,812</td>
</tr>
<tr>
<td>FEMALE, 55-59</td>
<td>13,910</td>
<td>10,660</td>
<td>5,339</td>
</tr>
<tr>
<td>FEMALE, 60-64</td>
<td>17,019</td>
<td>13,128</td>
<td>6,252</td>
</tr>
<tr>
<td>FEMALE, 65-69</td>
<td>153,494</td>
<td>123,930</td>
<td>3,582</td>
</tr>
<tr>
<td>FEMALE, 70-74</td>
<td>225,947</td>
<td>174,769</td>
<td>4,240</td>
</tr>
<tr>
<td>FEMALE, 75-79</td>
<td>196,701</td>
<td>151,771</td>
<td>5,279</td>
</tr>
<tr>
<td>FEMALE, 80-84</td>
<td>147,547</td>
<td>112,884</td>
<td>6,374</td>
</tr>
<tr>
<td>FEMALE, 85-89</td>
<td>92,649</td>
<td>69,128</td>
<td>7,445</td>
</tr>
<tr>
<td>FEMALE, 90-94</td>
<td>43,172</td>
<td>31,136</td>
<td>8,095</td>
</tr>
<tr>
<td>FEMALE, 95 OR OLDER</td>
<td>14,971</td>
<td>10,909</td>
<td>7,434</td>
</tr>
<tr>
<td>MALE, &lt;=34</td>
<td>12,020</td>
<td>10,874</td>
<td>3,305</td>
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### Table 4-7 (continued)

Frequencies and Mean Expenditures by Validation Group

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<td>13,278</td>
<td>17,898</td>
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</table>

| **Expenditures**                                                          |                |                   |                        |
| FIRST (LOWEST) QUINTILE, 1996 EXPEND                                       | 278,939        | 270,960           | 1,885                  |
| SECOND QUINTILE, 1996 EXPEND                                               | 278,941        | 271,509           | 2,688                  |
| MIDDLE QUINTILE, 1996 EXPEND                                               | 278,940        | 270,259           | 3,886                  |
| FOURTH QUINTILE, 1996 EXPEND                                               | 278,940        | 268,646           | 5,686                  |
| FIFTH (HIGHEST) QUINTILE, 1996 EXPEND                                      | 278,941        | 257,272           | 12,807                 |
| Top 5 percent 1996                                                        | 69,736         | 61,743            | 20,610                 |
| Top 1 percent 1996                                                        | 13,948         | 11,851            | 32,578                 |
| FIRST (LOWEST) QUINTILE, 1997 EXPEND                                       | 278,938        | 266,369           | 27                      |
| SECOND QUINTILE, 1997 EXPEND                                               | 278,941        | 274,039           | 284                    |
| MIDDLE QUINTILE, 1997 EXPEND                                               | 278,941        | 273,830           | 894                    |
| FOURTH QUINTILE, 1997 EXPEND                                               | 278,940        | 272,685           | 3,155                  |
| FIFTH (HIGHEST) QUINTILE, 1997 EXPEND                                      | 278,941        | 251,724           | 23,534                 |
| No home health spending 1996                                              | 1,255,390      | 1,211,548         | 4,260                  |
| Home health spending > 0 1996                                             | 139,311        | 127,100           | 15,359                 |
| HHA spending > 0: FIRST (LOWEST) QUINTILE, 1996                           | 29,668         | 27,520            | 10,029                 |
| HHA spending > 0: SECOND QUINTILE, 1996                                   | 29,196         | 27,042            | 10,626                 |
| HHA spending > 0: MIDDLE QUINTILE, 1996                                   | 28,136         | 25,735            | 13,049                 |
| HHA spending > 0: FOURTH QUINTILE, 1996                                   | 26,639         | 23,981            | 16,803                 |
| HHA spending > 0: FIFTH (HIGHEST) QUINTILE, 1996                          | 25,672         | 22,822            | 28,483                 |
| HHA spending > 0: top 10% of HHA spending 1996                           | 12,803         | 11,298            | 34,924                 |
| HHA spending > 0: top 5% of HHA spending 1996                            | 6,360          | 5,594             | 41,981                 |
| No DME spending 1996                                                      | 1,172,915      | 1,133,321         | 4,213                  |
| DME spending > 0 1996                                                     | 221,786        | 206,327           | 11,356                 |
| DME spending > 0: FIRST (LOWEST) QUINTILE, 1996                           | 48,292         | 46,052            | 7,663                  |
| DME spending > 0: SECOND QUINTILE, 1996                                   | 46,432         | 43,736            | 9,527                  |
| DME spending > 0: MIDDLE QUINTILE, 1996                                   | 45,434         | 42,688            | 9,730                  |
| DME spending > 0: FOURTH QUINTILE, 1996                                   | 42,830         | 39,446            | 12,711                 |
| DME spending > 0: FIFTH (HIGHEST) QUINTILE, 1996                          | 38,798         | 34,405            | 19,087                 |
| DME spending > 0: top 10% of DME spending 1996                           | 19,888         | 17,528            | 20,944                 |
| DME spending > 0: top 5% of DME spending 1996                            | 9,623          | 8,400             | 24,313                 |
| No DME spending 1997                                                      | 1,145,230      | 1,101,907         | 3,291                  |

Health Economics Research, Inc. DCG/HCC Models for Medicare Risk Adjustment: 4-53
Table 4-7 (continued)

Frequencies and Mean Expenditures by Validation Group

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<td>DME spending&gt;0:MIDDLE QUINTILE, 1997</td>
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<td>DME spending&gt;0:FOURTH QUINTILE, 1997</td>
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<td>DME spending&gt;0:FIFTH (HIGHEST) QUINTILE,1997</td>
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<td>DME spending&gt;0: top 5% of DME spending 1997</td>
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<td>walkers (DME)</td>
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<td>0 1997 HOSP ADMISSIONS</td>
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NOTES:
1 Validation group diagnoses assigned using Source=1-6.
² Expenditures are annualized and weighted by the fraction of the year eligible.

OUTPUT: D9pr07aa.out and D9pr02vc.out

### Table 4-8
Predictive Ratios for Age/Sex, All HCC, and Base HCC Models

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### Table 4-8 (continued)

Predictive Ratios for Age/Sex, All HCC, and Base HCC Models

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<td>0.91</td>
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#### Multiple Diagnoses

- DIABETES, CORONARY ARTERY DISEASE: 0.44, 0.96, 0.98
- DIABETES, CEREBROVASCULAR DISEASE: 0.39, 0.94, 0.98
- HEART FAILURE, COPD: 0.36, 0.93, 0.98
- CORONARY ARTERY DISEASE, VASCULAR DISEASE: 0.43, 0.97, 0.97
- COPD, CORONARY ARTERY DISEASE: 0.42, 0.97, 0.99
- HEART FAILURE, RENAL FAILURE: 0.28, 0.93, 0.98
- DIABETES, HEART FAILURE, RENAL FAILURE: 0.22, 0.88, 0.98
- COPD, CEREBROVASCULAR DISEASE, CORONARY ARTERY DISEASE: 0.33, 0.94, 0.99
- DIABETES, CEREBROVASCULAR DISEASE, VASCULAR DISEASE: 0.32, 0.95, 0.99

#### Expenditures

<table>
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<tr>
<th>Expenditures</th>
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<td>FIRST (LOWEST) QUINTILE, 1996 EXPEND</td>
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<tr>
<td>SECOND QUINTILE, 1996 EXPEND</td>
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</tr>
<tr>
<td>MIDDLE QUINTILE, 1996 EXPEND</td>
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<tr>
<td>FOURTH QUINTILE, 1996 EXPEND</td>
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</tr>
<tr>
<td>FIFTH (HIGHEST) QUINTILE, 1996 EXPEND</td>
<td>0.44</td>
</tr>
</tbody>
</table>

**Top 5 percent 1996**
- 0.28, 0.79, 0.77
- 0.17, 0.69, 0.69

**Top 1 percent 1996**
- 0.22, 0.47, 0.46
- 0.18, 0.39, 0.39
- 0.15, 0.34, 0.33

**No home health spending 1996**
- 1.23, 1.09, 1.10
- 0.39, 0.77, 0.75
- 0.58, 1.02, 0.99
- 0.56, 1.02, 0.98
- 0.96, 1.01, 0.98
- 0.46, 0.91, 0.88
- 0.36, 0.77, 0.75
- 0.22, 0.47, 0.46
- 0.18, 0.39, 0.39
- 0.15, 0.34, 0.33

**Home health spending > 0 1996**
- 1.68, 1.53, 1.54
- 0.26, 0.41, 0.41
- 0.40, 0.54, 0.53
- 0.34, 0.48, 0.47
- 0.29, 0.44, 0.43
- 0.24, 0.40, 0.39
- 0.17, 0.33, 0.32
- 0.14, 0.30, 0.29
- 0.12, 0.27, 0.26

**No DME spending 1996**
- 1.25, 1.08, 1.09
- 0.49, 0.84, 0.82
- 0.72, 0.99, 0.94
- 0.59, 0.94, 0.89
Table 4-8 (continued)

Predictive Ratios for Age/Sex, All HCC, and Base HCC Models

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<th>Group Label</th>
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<th>3</th>
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<tr>
<td>DME spending&gt;0: MIDDLE QUINTILE, 1996</td>
<td>0.57</td>
<td>0.92</td>
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<td>DME spending&gt;0: FOURTH QUINTILE, 1996</td>
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<td>0.84</td>
<td>0.82</td>
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<td>0.59</td>
<td>0.59</td>
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<tr>
<td>DME spending&gt;0: top 5% of DME spending, 1996</td>
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<td>0.57</td>
<td>0.57</td>
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<tr>
<td>No DME spending, 1997</td>
<td>1.60</td>
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<tr>
<td>DME spending &gt; 0, 1997</td>
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<td>0.58</td>
<td>0.57</td>
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<tr>
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<td>0.18</td>
<td>0.44</td>
<td>0.44</td>
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</tbody>
</table>

### DME

- oxygen supplies/equipment (DME): 0.29, 0.65, 0.65
- wheelchairs (DME): 0.34, 0.69, 0.68
- walkers (DME): 0.45, 0.88, 0.84

### HOSPITAL ADMISSIONS

| 0 1996 HOSP ADMISSIONS | 1.33 | 1.01 | 1.03 |
| 1 1996 HOSP ADMISSIONS | 0.63 | 1.06 | 1.02 |
| 2 1996 HOSP ADMISSIONS | 0.44 | 1.01 | 0.98 |
| 3+ 1996 HOSP ADMISSIONS | 0.26 | 0.83 | 0.82 |

| 0 1997 HOSP ADMISSIONS | 4.02 | 3.50 | 3.53 |
| 1 1997 HOSP ADMISSIONS | 0.45 | 0.57 | 0.56 |
| 2 1997 HOSP ADMISSIONS | 0.23 | 0.34 | 0.34 |
| 3+ 1997 HOSP ADMISSIONS | 0.12 | 0.25 | 0.24 |

**NOTES:**

1 Validation group diagnoses assigned using Source=1-6.

**OUTPUT:** D9pr07aa.out

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
Table 4-9

Base HCC Model with Medicaid and Ever Disabled Factors Interacted with Age/Sex

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<th>t-ratio</th>
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Demographic Interactions

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<td>HCC3</td>
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<td>Other Infectious Diseases</td>
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Table 4-9 (continued)

Base HCC Model with Medicaid and Ever Disabled Factors Interacted with Age/Sex

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<td>Completed Pregnancy With Complications</td>
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<td>HCC145</td>
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<td>Cellulitis, Local Skin Infection</td>
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<td>HCC153</td>
<td>Other Dermatological Disorders</td>
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<td>HCC154</td>
<td>Severe Head Injury</td>
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<td>Major Fracture, Except of Skull, Vertebrae, or Hip</td>
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<td>HCC161</td>
<td>Traumatic Amputation¹</td>
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<td>HCC162</td>
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<td>HCC163</td>
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<td>Major Symptoms, Abnormalities</td>
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<td>HCC176</td>
<td>Artificial Openings for Feeding or Elimination</td>
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| Variable     | Label                                | Parameter | Estimate | t-ratio | Number of Observations for Interacted Categories
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<td>CPAP/IPPB/Nebulizers</td>
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<td>Patient Lifts, Power Operated Vehicles, Beds</td>
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<td>HCC188</td>
<td>Wheelchairs, Commodes</td>
<td></td>
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<td>HCC189</td>
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<td>DISABLED*OPPORTUNISTIC INFECTIONS</td>
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<td>2.64</td>
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<td>D_HCC72</td>
<td>DISABLED* MULTIPLE SCLEROSIS</td>
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<td>D_HCC107</td>
<td>DISABLED* CYSTIC FIBROSIS</td>
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<td>INT1</td>
<td>DM *CHF</td>
<td>1,038</td>
<td>11.99</td>
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<tr>
<td>INT2</td>
<td>DM *CVD</td>
<td>560</td>
<td>6.32</td>
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<td>INT3</td>
<td>CHF *COPD</td>
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<td>INT4</td>
<td>COPD*CVD *CAD</td>
<td>524</td>
<td>4.55</td>
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<td>INT5</td>
<td>RF*CHF</td>
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<td>INT6</td>
<td>RF<em>CHF</em>DM</td>
<td>1,665</td>
<td>5.83</td>
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**NOTES:**
- Diagnoses assigned using Source=1-5.
- Coefficients of HCCs 161 and 177 are constrained to be equal.
- Number of observations for interacted categories is person years.
- "|" means coefficients of HCCs are constrained to be equal.
- DM= diabetes mellitus (HCCs 15-20)
- CHF= congestive heart failure (HCC 80)
- COPD= chronic obstructive pulmonary disease (HCC 108)
- CVD= cerebrovascular disease (HCCs 95-103)
- VD= vascular disease (HCCs 104-105)
- CAD= coronary artery disease (HCCs 81-84)
- RF=renal failure (HCC 131)

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
### Table 4-10

Mean Actual and Predicted Expenditures by Age and Sex for Working Aged

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<th></th>
<th>Frequency</th>
<th>1997 Person Years</th>
<th>Actual Mean Payment</th>
<th>Mean Predicted Expenditures</th>
<th>Actual/Predicted</th>
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<td>Total</td>
<td>20,526</td>
<td>17,870</td>
<td>$945</td>
<td>$3,293</td>
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<td>Male, Total</td>
<td>12,455</td>
<td>10,811</td>
<td>971</td>
<td>3,614</td>
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<td>MALE &lt;65</td>
<td>229</td>
<td>120</td>
<td>1,064</td>
<td>5,652</td>
<td>0.188</td>
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<td>MALE 65-69</td>
<td>5,768</td>
<td>5,071</td>
<td>781</td>
<td>3,177</td>
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<td>MALE 70-74</td>
<td>3,950</td>
<td>3,482</td>
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<td>MALE 75-79</td>
<td>1,786</td>
<td>1,536</td>
<td>1,173</td>
<td>4,325</td>
<td>0.271</td>
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<tr>
<td>MALE 80+</td>
<td>722</td>
<td>603</td>
<td>1,646</td>
<td>5,508</td>
<td>0.299</td>
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<tr>
<td>Female, Total</td>
<td>8,071</td>
<td>7,060</td>
<td>905</td>
<td>2,802</td>
<td>0.323</td>
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<td>FEMALE &lt;65</td>
<td>63</td>
<td>27</td>
<td>1,685</td>
<td>5,698</td>
<td>0.296</td>
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<td>FEMALE 65-69</td>
<td>3,774</td>
<td>3,300</td>
<td>709</td>
<td>2,402</td>
<td>0.295</td>
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<tr>
<td>FEMALE 70-74</td>
<td>2,664</td>
<td>2,343</td>
<td>772</td>
<td>2,772</td>
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<td>FEMALE 75-79</td>
<td>1,118</td>
<td>1,000</td>
<td>1,190</td>
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<td>FEMALE 80+</td>
<td>452</td>
<td>390</td>
<td>2,579</td>
<td>4,626</td>
<td>0.558</td>
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**NOTES:**

1 Age is calculated as of January 1, 1997. People in this category turned 65 years old in 1997. Weighting variable is WAM97AD/12 (taking both working and eligible months into account).

**OUTPUT:** D9pr23.out

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
In Chapter 4, we estimated models based on diagnostic categories (HCCs) assigned from hospitals, physicians, and clinically-trained nonphysicians (psychologists, podiatrists, etc.). We found that these models generally performed well, but underpredicted the mean expenditures of some subgroups of beneficiaries, in particular those utilizing home health and durable medical equipment (DME) in the base year. One means of improving model performance may be to incorporate diagnoses from additional sources, or sites of care. For example, perhaps the expenditures of home health utilizers can be predicted more accurately if home health diagnoses are also used to assign diagnostic categories. If home health users also have doctor and hospital visits, and their diagnoses are recorded in these settings, one would expect little improvement from adding home health diagnoses. But if home health users do not have these other types of utilization, or if their complete diagnostic profiles are not recorded in other settings, then incorporating home health diagnoses could significantly improve model performance for this group. In this chapter, we calibrate models with alternative sources of diagnoses, and then evaluate their performance.

The potential benefit of additional sources of diagnoses is increased overall predictive power, and greater accuracy for particular subgroups of beneficiaries. We examine the magnitude of these benefits in the Medicare fee-for-service population in this chapter. There are potential benefits of collecting additional data types beyond
diagnoses for risk adjustment. First, these data can be valuable in profiling HMO costs, so that HMO cost data can be used in recalibrating future risk adjustment and payment models. If HMO coding and expenditure patterns are different from fee-for-service, recalibration using actual HMO data could be very important for payment accuracy. Second, additional data types are important for producing quality measures, many of which are based on whether certain types of care are being provided.

Adding sources of diagnoses also has disadvantages for Medicare managed care capitation payment. The most important disadvantage is that it may be costly to collect, process, and audit encounter data collection from additional sites of care. Not only must Medicare+Choice plans and providers incur the costs of recording, preparing, and submitting these additional encounter records (containing diagnoses) to HCFA, but HCFA would need to establish standards and procedures (including auditing) for collecting and processing the added information. The incremental benefits from using additional sources of diagnoses may not justify their costs.\(^1\) A second disadvantage or question about additional sources of diagnoses is their clinical validity. Diagnoses established by clinicians or trained medical record personnel at hospitals or physicians' clinics are presumed to be more accurate than diagnoses submitted by home health agencies or DME suppliers in most instances. Strict Medicare rules defining diagnoses that are required in order for a beneficiary to be eligible for home health and DME may encourage these providers to code certain diagnoses in order to qualify for reimbursement.

\(^1\) Although we note that the size of the data flow from the alternative sources is relatively small compared to the flow from the very important physician source, which HCFA is already committed to collecting.
even if the patient has never been officially diagnosed for this condition by a clinician. Evaluating the data collection cost and clinical validity of alternative sources of diagnoses is beyond the scope of this report. But these costs/disadvantages of additional diagnosis sources should be kept in mind as we assess potential benefits in this chapter.

Another issue related to source of diagnoses is how sensitive predicted payments from the base risk adjustment model are to alternative sets of diagnoses. Medicare+Choice plans have different data systems and patterns of care. In practice, they are likely to submit diagnoses from somewhat different sites or types of care to HCFA. Ideally, the payment model would be relatively insensitive to variations in the types of diagnoses submitted. To analyze this issue, we conducted simulations of predicted payments with alternative sets of diagnoses, without recalibrating the parameters of the base payment model. Results of these simulations are reported in Section 5.3.

5.1 Alternative Models

Table 5-1 reviews the 9 categories (some with subcategories) into which we classified the diagnoses available on Medicare fee-for-service claims. The first 5 sources—hospital, physician, and clinically-trained nonphysician diagnoses--are the base set of diagnoses that we use to estimate our models, in particular our base prospective risk adjustment model, Model 5 of Table 4-2. For this analysis, we estimated our base model with six alternative sets of diagnoses:
Chapter 5  Model Estimation and Validation with Additional Sources of Diagnoses

1. Hospital and physicians only, excluding radiologists, anesthesiologists, and pathologists (RAPs) (Source = 1-3, 4a).

2. Hospital, physician, clinically-trained nonphysician (base set of diagnoses; Sources 1-5);

3. Model 2 + home health agency (Source = 1-5, 6b);

4. Model 3 + skilled nursing facility (SNF), ambulatory surgery center (ASC), and hospice (Source = 1-6);

5. Model 4 + durable medical equipment (DME) (Source = 1-6 and 8a)\(^2\);

and

6. Model 5 + clinical laboratory, radiology/imaging clinics, miscellaneous (includes all diagnoses, Source = 1-9).

Model 2 uses our base set of diagnoses, and is the baseline that other models should be compared to. Model 1 is the only model variant estimated with fewer diagnoses than our base model. It was motivated by concern that the diagnoses of radiologists, anesthesiologists, and pathologists (RAPs) may be less clinically valid in general than those of other physicians because RAPs are less likely to spend "face-to-face" time with patients. In addition, larger proportions of "rule out" diagnoses may appear on the claims of radiologists and pathologists in particular. Model 1 also excludes the diagnoses of clinically-trained nonphysicians—which may be less reliable--from the base set of diagnoses. Models 3-6 cumulatively add sources of diagnoses to the base set.

5.2 Results

Table 5-2 presents estimates of Models 2-6 defined in the previous section. Table 5-3 contains estimates of Model 1 together with Model 2 for comparison. Percentage of

\(^2\) We also examined including DME diagnoses from Part B claims (Source 8b), but there were very few. For simplicity, we excluded these from our analyses.
individual expenditure variation (R-square) predicted by the alternative models is summarized in Table 5-4. Predictive ratios for the 6 models are shown in Table 5-5.

5.2.1 Excluding RAP and Clinically-Trained Nonphysician Diagnoses

Excluding radiologist, anesthesiologist, and pathologist (RAP) and clinically-trained nonphysician diagnoses from the base set of diagnoses reduces predictive power by a small, but detectable amount. The R-square falls from 11.15 percent to 11.03 percent (Table 5-4). This indicates that RAP and clinically-trained nonphysician diagnoses contain information not duplicated in other hospital or physician diagnoses that is useful in predicting future expenditures. But the gain in predictive accuracy is small enough that incurring substantial expenditures to obtain these diagnoses may not be warranted. On the other hand, it may be more expensive and complex in practice to exclude RAP diagnoses rather than to simply collect all physician diagnoses.

In general, the coefficient estimates of Model 1 are larger than those of Model 2 (Table 5-3). The smaller set of diagnoses of Model 1 appears to identify a smaller number of more severely ill beneficiaries. Most likely some of the RAP diagnoses reflect false positive values that are eventually ruled out. There are few differences in predictive accuracy by Medicare subgroup when the diagnoses are restricted to the Model 1 set (Table 5-5). Evaluating the clinical validity of the diagnoses excluded from Model 1 (RAP, clinically-trained nonphysician) is beyond the scope of this report. Therefore, we can reach no firm conclusions on whether excluding these diagnoses is appropriate other than to note that the impact of including them on predictive power is relatively small.
5.2.2 Adding Home Health Diagnoses

Adding home health agency diagnoses to the base set increases predictive power by a sizeable one-half percentage point, from 11.15 percent to 11.65 percent (Table 5-4). Apparently a substantial number of home health utilizers are not receiving duplicative diagnoses in other settings such as the hospital and physician office. There is no marked general difference in coefficient estimates by diagnostic category (HCC) when home health diagnoses are added (compare Models 1 and 2 in Table 5-2). Coefficients appear to be randomly higher or lower by HCC, indicating that home health diagnoses are identifying more beneficiaries of similar cost levels to those identified by hospital and physician diagnoses. One exception is HCC 148, Decubitus Ulcer of Skin, which has nearly a $1,000 higher coefficient when home health diagnoses are included.

The 25 most frequent diagnoses on home health claims are shown in Table 5-6. Some notable frequent diagnoses are heart failure, osteoarthritis, coronary atherosclerosis, chronic obstructive pulmonary disease (emphysema/chronic bronchitis), diabetes, and stroke (cerebrovascular accident). These diagnoses are unremarkable, but we did not attempt to validate them (e.g., against non-home health diagnoses). It is perhaps surprising that DxGroup 96.02 "cerebrovascular accident, unspecified" is so common since this is an acute stroke diagnosis. More likely, home health care is for the sequelae of stroke, and this diagnosis is miscoded (ICD-9-CM includes diagnosis codes for the "late effects" of stroke that should be coded for non-acute care).

Adding home health diagnoses improves the base model's predictive accuracy for home health utilizers, but not dramatically. Among all beneficiaries utilizing home
health in the base year, the percentage of mean total expenditures predicted by the model rises from 75 percent to 79 percent when home health diagnoses are added to hospital and physician diagnoses. Among beneficiaries with the highest 5 percent of prior year home health spending, the percentage of total expenditures predicted increases from 33 percent to 37 percent. The gains in predictive accuracy for beneficiaries grouped by total prior year expenditures are even smaller. For example, the percentage of mean total expenditure variation predicted rises from 86 percent to 88 percent for the top quintile of prior year spenders when home health diagnoses are added. Overall, adding home health diagnoses results in a noticeable, but not dramatic gain of the predictive accuracy of the base model.

5.2.3 Adding SNF, ASC, and Hospice Diagnoses

Adding skilled nursing facility (SNF), ambulatory surgery center (ASC), and hospice diagnoses to the base set plus home health diagnoses results in no increase in explanatory power for individuals (no change in R-square, Table 5-4). There is also no change in predictive accuracy for groups (no change in predictive ratios, Table 5-5). Differences in parameter estimates (Table 5-2) are inconsequential. Any information in SNF, ASC or hospice diagnoses with predictive value is duplicated in the base set of diagnoses or home health diagnoses. There appears to be no justification for incurring the expense of collecting diagnoses from these sites of care for risk adjustment. However, it may still be desirable to collect data on these patient encounters for model recalibration or computation of quality measures.
5.2.4 Adding Durable Medical Equipment Diagnoses

Adding durable medical equipment (DME) diagnoses, on the other hand, does improve predictive power by a noticeable amount (Table 5-4). The R-square rises from 11.65 percent to 11.85 percent. At least some DME utilizers are not receiving duplicative hospital, physician, or other facility (home health, SNF, ASC, hospice) diagnoses. The biggest difference in coefficient estimates (Table 5-2) is a lower estimate for HCCs 67 and 68 Quadriplegia and Paraplegia (whose coefficients are constrained to be equal to preserve monotonicity) when DME diagnoses are included. DME diagnoses identify more beneficiaries with these paralytic conditions, but the newly identified people have lower future costs than those identified through diagnoses on other claims. The 25 most frequent diagnoses on DME claims are shown in Table 5-7. Many diagnoses are also among the most frequent home health diagnoses (Table 5-6), including chronic obstructive pulmonary disease (emphysema/chronic bronchitis), osteoarthritis, diabetes, heart failure, and stroke (cerebrovascular accident).

Adding DME diagnoses improves predictive accuracy for prior year DME utilizers by a detectable, but small amount. For all prior year DME utilizers, the percentage of mean total expenditures predicted rises from 84 percent to 87 percent when DME diagnoses are included (Table 5-5). For the highest prior year DME utilizers the percentage of mean total expenditures predicted increases from 59 percent to 64 percent. Accuracy also improves for beneficiaries using particular types of DME. For example, among beneficiaries receiving wheelchairs in the base year, the percentage of mean total expenditures predicted grows from 72 percent to 77 percent when DME diagnoses are
added. The prediction of mean total expenditures for base year home health utilizers is also slightly improved by adding DME diagnoses. For example, the predictive ratio for the highest prior year home health utilizers increases from 37 percent to 39 percent. However, only very slight improvement in prediction across total expenditure quantiles occurs when DME diagnoses are added (Table 5-5). Overall, adding DME diagnoses results in a detectable, but small improvement in expenditure prediction.

5.2.5 Adding All Other Diagnoses

Adding the remaining diagnoses (Model 6) actually reduces the percentage of individual expenditure variation predicted slightly (Table 5-4). The R-square falls from 11.85 percent to 11.82 percent. The diagnoses added in Model 6 include clinical laboratory and radiology/imaging clinics, which may contain many rule out, false positive, etc. diagnoses that are inaccurate, or codes assigned by clinically-trained nonphysicians. Including these diagnoses in risk adjustment should be avoided.

5.3 Implications of Including or Omitting Diagnoses for Predicted Payments

This section examines the implications of erroneously including or omitting sets of diagnoses when calculating payments using the base prospective risk adjustment model (Model 5 of Table 4-2). Since Medicare+Choice plans may differ in practice settings and use of different provider specialties, one would expect variation in sources of diagnoses, even if there is no “gaming” to take advantage of the particular features of a
risk adjustment payment system. A desirable feature of a payment model is that the level of payments is relatively insensitive to variations in what diagnoses are included or omitted. Therefore, it is informative to consider the magnitude of the overpayment problem when diagnoses are included and underpayment when diagnoses are omitted. In practice, it may be unlikely that ALL diagnoses from a setting would be erroneously included or excluded. The simulations in this section establish upper or lower bounds for misreporting effects.

To address the misreporting issue, a series of simulations was performed adding or omitting sets of diagnoses when calculating predicted payments. Sets of diagnoses were added or excluded as previously defined in Section 5.1, and new diagnostic categories (HCCs) assigned to each person in light of the set of diagnoses considered. In all simulations, the parameters from the base payment model were used to calculate payments for demographic and diagnostic (HCC) variables. Demographic variables remain unchanged. The only changes made were in the assignment of HCCs. As in the base model, hierarchies and exclusions are made, and interactions between HCCs and disability status are also calculated. All simulations shown in this section did NOT recalibrate payment (regression) coefficients using the different diagnostic information.

Table 5-8 presents the results at an aggregate level for the inclusion and omission of various sets of diagnoses. The first column assigns each simulation a run number, while the second column lists the sources of diagnoses that are included in the simulation run. The Description column summarizes how the run differs from the base model, with each set of diagnoses excluded sequentially, rather than one at a time. The fourth column
shows the predicted payments, which as just described reflect payment parameters for the base model with HCCs recalculated using the diagnostic information shown. The final column expresses predicted payments as a ratio of the simulation run prediction to the base model prediction. Note that these are NOT predictive ratios, as used extensively elsewhere in this report. Rather, they are the ratio of predicted payments using the current set of diagnoses divided by predicted payments using the original, base model. Ratios greater than one indicate overpayment relative to the base model, while numbers less than one indicate underpayment relative to the base model. A ratio of one would indicate that payments are unaffected by including or omitting diagnoses, and that total payments remain $5,314.

A reassuring result is that predictions are relatively insensitive to whether diagnoses that appear on home health agency (HHA), or skilled nursing facility plus ambulatory surgery center claims are erroneously included, with predicted payments increasing by 1 and 2 percent respectively. Adding in diagnoses that appear on medical supplies/DME claims has a slightly greater further effect, raising predicted payments to 4 percent above the base level prediction. The “kitchen sink” approach of including any diagnosis regardless of its source increases payment to 7 percent above the base level amount, which is $246. Readers may differ on whether a potential 7 percent overpayment is a large or small amount. Our own interpretation is that 7 percent is a relatively small increment, given the magnitude of claims diagnoses that are being incorrectly included while calculating risk scores.
The bottom half of Table 5-8 simulates the impact of selectively omitting diagnoses when calculating payments. Omitting only diagnoses that are coded by clinically-trained nonphysicians reduces predictions by 2 percent, a relatively small reduction. Payments are much more dramatically affected by omitting all of the diagnoses that are coded by physicians, which reduces payments to $3,682, or 69 percent of the baseline prediction. Omitting hospital outpatient department diagnoses reduces payments by another 10 percent, to $3,133 (59 percent of base predictions). From this point on, dropping additional sets of diagnoses has relatively little impact. Dropping all secondary inpatient diagnoses reducing predicted payments to $2,560, 48 percent of the base model prediction. Note that in this case predicted payments are based only on principal inpatient room and board claims. Even when no diagnoses are used for calculating payments (and predictions are based on demographic factors only), predictions remain 43 percent of the base model level.

Table 5-9 provides an in-depth view of how including or omitting selected classes of diagnoses affects payments not only in aggregate, but also for the various validation groups that have been identified. In this table, the first two columns describe the validation groups, and the next two columns summarize mean actual and mean predicted payments from each validation group using parameters from the base model. The last 10 columns of Table 5-9 present the results of simulating each of the 10 simulation runs in ratio terms. The numerator of each ratio is the mean predicted payments for each run and for each validation group, while the denominator of each ratio is the mean prediction for the base model.
These detailed results by validation group reveal that including or omitting sets of diagnoses have a remarkably similar impact on many different Medicare subgroups. Adding only home health agency (HHA) diagnoses on average increases payments by 1 percent in the entire sample, but increases them by 3 percent for males and females aged 95 and older, and by as much as 3 percent for various quintiles of spending or selected chronic conditions. Adding HHA diagnoses is particularly effective at increasing payments to persons with significant HHA spending, as would be expected, increasing payments for selected high cost groups by as much as 12 percent. As further diagnoses are included, predicted spending in all groups rises, however there is considerable uniformity in predicted payments across diverse subsets of the population.

Simulations in which sets of diagnoses are omitted when predicting payments are shown in the last 5 columns of Table 5-9. Here again there is considerable similarity in the impact of omitting diagnoses on predicted payments by the various validation groups. The simulation using simulation 6, which omits providers who are clinically-trained nonphysicians, shows payments for every group that range from 94 percent to 100 percent of the base prediction, with an average of 98 percent. This seems to us to be a fairly tight range.

The final column of Table 5-9 is interesting in that it displays the magnitude of payments even if payments are based solely on the demographic characteristics of a population subsample rather than on both demographic and diagnostic information. Payments to the disabled Medicare population are noticeably more dependent on diagnostic payments than payments to aged Medicare enrollees, with the demographic
component being 28 percent of total for disabled sample versus 45 percent for the aged sample. Somewhat surprising is that the demographic component is higher for older age groups than for younger groups. For instance the demographic component contributes 50 percent of the total for males, aged 90-94, versus only 41 percent for females aged 65-69, and 23 percent for males aged 25-34. Apparently, spending that is not predicted by various chronic conditions play a larger role in the health costs of the oldest old than spending in younger groups. Not surprising is that diagnostic information plays a much larger role in various high expenditure quintiles and groups defined by chronic conditions, where spending predicted by demographics is estimated at only 7 to 12 percent for some validation groups.

Overall, we see these simulations as encouraging. Our assessment is that payments are moderately, not severely, affected by changes in the information used. Increases on the order of 1 or 2 percent occur from including home health, nursing facility and ambulatory surgery center diagnoses. Of course, a 7 percent overpayment is of concern if plans were to be allowed to include diagnoses appearing on all types of claims, but presumably this type of massive reclassifying would be subject to audit. Ignoring claims by all non-clinicians reduces payments by only 2 percent, a relatively modest impact. Excluding all physician claims has a dramatic effect and disproportionately affects certain chronic diseases, but it would be surprising if this were not true. We take the moderate sensitivity of predictions to rather broad simulations using different sets of diagnoses as a sign that we have successfully excluded some of the less serious, discretionary, and prevalent diagnoses from our DCG/HCC payment model.
<table>
<thead>
<tr>
<th>Source Number</th>
<th>Sites of Care/Claim Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>hospital inpatient—principal diagnoses</td>
</tr>
<tr>
<td>2</td>
<td>hospital inpatient—secondary diagnoses</td>
</tr>
<tr>
<td>3</td>
<td>hospital outpatient department</td>
</tr>
<tr>
<td>4</td>
<td>physician</td>
</tr>
<tr>
<td>4a</td>
<td>physicians, excluding RAPs</td>
</tr>
<tr>
<td>4b</td>
<td>radiologist, anesthesiologist, pathologist (RAPs)</td>
</tr>
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<td>5</td>
<td>clinically-trained nonphysician (e.g., psychologist, therapist, podiatrist)</td>
</tr>
<tr>
<td>6</td>
<td>facility types</td>
</tr>
<tr>
<td>6a</td>
<td>ambulatory surgery center</td>
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<tr>
<td>6b</td>
<td>home health agency</td>
</tr>
<tr>
<td>6c</td>
<td>skilled nursing facility</td>
</tr>
<tr>
<td>6d</td>
<td>hospice</td>
</tr>
<tr>
<td>7</td>
<td>diagnostic testing</td>
</tr>
<tr>
<td>7a</td>
<td>non-laboratory, e.g., radiology imaging clinics</td>
</tr>
<tr>
<td>7b</td>
<td>clinical laboratory</td>
</tr>
<tr>
<td>8</td>
<td>durable medical equipment/medical supplies</td>
</tr>
<tr>
<td>8a</td>
<td>DME diagnosis from DME Standard Analytic File</td>
</tr>
<tr>
<td>8b</td>
<td>DME diagnosis from Part B file</td>
</tr>
<tr>
<td>9</td>
<td>other/miscellaneous</td>
</tr>
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**SOURCE:** Health Economics Research, Inc.
### Table 5-2

**HCC Prospective Risk Adjustment Models with Additional Sources of Diagnoses**

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<thead>
<tr>
<th>Base</th>
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<th>3</th>
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<tr>
<td></td>
<td>Hosp, MD²</td>
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<td>SNF,ASC,HSP²</td>
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<td>All Dxs²</td>
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<td>0.1181</td>
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<tr>
<td>Adjusted R-Square</td>
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<td>0.1164</td>
<td>0.1165</td>
<td>0.1184</td>
<td>0.1181</td>
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<td>5,314</td>
<td>5,314</td>
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<tr>
<td>Root Mean Square Error:</td>
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<td>12,993</td>
<td>12,978</td>
<td>12,980</td>
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<td>127</td>
<td>127</td>
<td>127</td>
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<td>D9pr02za.prt</td>
<td>D9pr02xa.prt</td>
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#### Variable Label

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<th>Parameter Estimate</th>
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</tr>
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</table>

#### Demographics

- **Male, 0-34**: $211 \times 1.63$
- **Male, 35-44**: $360 \times 3.79$
- **Male, 45-54**: $676 \times 8.01$
- **Male, 55-59**: $1,042 \times 9.14$
- **Male, 60-64**: $1,468 \times 14.25$
- **Male, 65-69**: $1,462 \times 34.14$
- **Male, 70-74**: $1,932 \times 50.69$
- **Male, 75-79**: $2,536 \times 58.59$
- **Male, 80-84**: $3,080 \times 56.53$
- **Male, 85-89**: $3,883 \times 49.59$
- **Male, 90-94**: $4,557 \times 33.64$
- **Male, 95+**: $3,919 \times 41.21$
- **Female, 0-34**: $403 \times 2.51$
- **Female, 35-44**: $648 \times 5.53$
- **Female, 45-54**: $880 \times 8.63$
- **Female, 55-59**: $1,134 \times 8.84$
- **Female, 60-64**: $1,724 \times 14.89$
- **Female, 65-69**: $2,121 \times 31.57$
- **Female, 70-74**: $1,613 \times 48.98$
- **Female, 75-79**: $2,165 \times 61.00$
- **Female, 80-84**: $2,716 \times 65.95$
- **Female, 85-89**: $3,305 \times 63.13$
- **Female, 90-94**: $3,710 \times 48.43$
- **Female, 95+**: $2,984 \times 23.52$
- **Prior Year Medicaid**: $927 \times 26.74$
- **Originally Disabled**: $1,392 \times 29.41$

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Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: 5-16
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<tr>
<th>Variable Label</th>
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<td>Tuberculosis</td>
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<td>Breast, Prostate, Colorectal and Other Cancers and Tumors</td>
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<tr>
<td>Other Digestive and Urinary Neoplasms</td>
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<td>Other Neoplasms</td>
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<td>Benign Neoplasms of Skin, Breast, Eye</td>
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<td>Diabetes with Neurologic or Peripheral Circulatory Manifestation</td>
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<td>Diabetes with Acute Complications</td>
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<td>Other Endocrine/Metabolic/Nutritional Disorders</td>
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<td>Cirrhosis of Liver</td>
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<td>Acute Liver Failure/Disease</td>
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### Table 5-2 (continued)

**HCC Prospective Risk Adjustment Models with Additional Sources of Diagnoses**

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**Ischemic or Unspecified Stroke**

Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: 5-19
Table 5-2 (continued)

HCC Prospective Risk Adjustment Models with Additional Sources of Diagnoses

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<td>0</td>
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<td>3,625</td>
<td>17.42</td>
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<td>HCC181</td>
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<tr>
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<td>0</td>
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<tr>
<td>HCC186</td>
<td>CPAP/IPPB/Nebulizers</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
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<tr>
<td>HCC188</td>
<td>Wheelchairs, Commodes</td>
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<td>HCC189</td>
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D_HCC5 DISABLED*OPPORTUNISTIC INFECTIONS | 3,892 | 5.67 | 3,861 | 5.71 | 3,881 | 5.75 | 3,687 | 5.50 | 3,675 | 5.62 |

D_HCC44 DISABLED*SEVERE HEMATOLOGICAL DISORDERS | 4,760 | 9.53 | 4,691 | 9.49 | 4,683 | 9.48 | 5,365 | 10.92 | 5,400 | 11.74 |

D_HCC45 DISABLED*DISORDERS OF IMMUNITY | 1,103 | 2.62 | 1,169 | 2.80 | 1,198 | 2.87 | 1,100 | 2.65 | 1,033 | 2.70 |

D_HCC46 DISABLED*COAGULATION DEFECTS | 1,999 | 7.51 | 1,771 | 6.83 | 1,762 | 6.80 | 1,815 | 7.02 | 1,935 | 8.32 |

D_HCC51 DISABLED*DRUG/ALCOHOL PSYCHOSIS | 4,010 | 11.29 | 4,112 | 11.69 | 4,111 | 11.71 | 4,160 | 11.92 | 3,973 | 11.51 |


D_HCC54 DISABLED* SCHIZOPHRENIA | 893 | 6.95 | 887 | 6.95 | 892 | 6.94 | 974 | 7.65 | 970 | 7.69 |

D_HCC72 DISABLED* MULTIPLE SCLEROSIS | 2,085 | 4.96 | 1,967 | 4.78 | 1,966 | 4.78 | 1,751 | 4.40 | 1,838 | 4.68 |

D_HCC107 DISABLED* CYSTIC FIBROSIS | 6,188 | 4.60 | 6,144 | 4.58 | 6,172 | 4.60 | 5,864 | 4.49 | 5,775 | 4.55 |
### Table 5-2 (continued)

**HCC Prospective Risk Adjustment Models with Additional Sources of Diagnoses**

<table>
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<tr>
<th>Variable</th>
<th>Label</th>
<th>Base</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT1</td>
<td>DM *CHF</td>
<td>1,036</td>
<td>1,067</td>
<td>1,067</td>
<td>1,053</td>
<td>991</td>
</tr>
<tr>
<td>INT2</td>
<td>DM *CVD</td>
<td>559</td>
<td>547</td>
<td>514</td>
<td>497</td>
<td>494</td>
</tr>
<tr>
<td>INT3</td>
<td>CHF *COPD</td>
<td>1,590</td>
<td>1,652</td>
<td>1,649</td>
<td>1,781</td>
<td>1,784</td>
</tr>
<tr>
<td>INT4</td>
<td>COPD*CVD *CAD</td>
<td>521</td>
<td>403</td>
<td>370</td>
<td>325</td>
<td>352</td>
</tr>
<tr>
<td>INT5</td>
<td>RF*CHF</td>
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<td>1,343</td>
<td>1,317</td>
<td>1,216</td>
<td>1,235</td>
</tr>
<tr>
<td>INT6</td>
<td>RF<em>CHF</em>DM</td>
<td>1,680</td>
<td>1,875</td>
<td>1,633</td>
<td>1,823</td>
<td>1,776</td>
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</table>

**Diagnoses Used for Estimation Added Cumulatively**

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<th>Hosp, MD</th>
<th>HHA</th>
<th>SNF, ASC, HSP</th>
<th>DME</th>
<th>All Dxs</th>
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<td>Parameter Estimate</td>
<td>t-ratio</td>
<td>Parameter Estimate</td>
<td>t-ratio</td>
<td>Parameter Estimate</td>
</tr>
<tr>
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<td>DM *CHF</td>
<td>1,036</td>
<td>11.97</td>
<td>1,067</td>
<td>12.49</td>
</tr>
<tr>
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<td>DM *CVD</td>
<td>559</td>
<td>6.31</td>
<td>547</td>
<td>6.27</td>
</tr>
<tr>
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<td>CHF *COPD</td>
<td>1,590</td>
<td>18.74</td>
<td>1,652</td>
<td>19.72</td>
</tr>
<tr>
<td>INT4</td>
<td>COPD*CVD *CAD</td>
<td>521</td>
<td>4.53</td>
<td>403</td>
<td>3.59</td>
</tr>
<tr>
<td>INT5</td>
<td>RF*CHF</td>
<td>1,435</td>
<td>6.27</td>
<td>1,343</td>
<td>5.95</td>
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<tr>
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<td>RF<em>CHF</em>DM</td>
<td>1,680</td>
<td>5.88</td>
<td>1,875</td>
<td>6.70</td>
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</table>

**NOTES:**

1. Source=1-5. Hosp=Hospital, MD=Physician. Also includes Clinically-Trained Non-Physicians.
2. Source=1-5, 6B. HHA = Home Health Agency.
3. Source=1-6. SNF = Skilled Nursing Facility; HSP = Hospice; ASC = Ambulatory Surgery Center.
4. Source=1-6, 8. DME = Durable Medical Equipment.

| DM= diabetes mellitus (HCCs 15-20) |
| CHF= congestive heart failure (HCC 80) |
| COPD= chronic obstructive pulmonary disease (HCC 108) |
| CVD= cerebrovascular disease (HCCs 95-103) |
| VD= vascular disease (HCCs 104-105) |
| CAD= coronary artery disease (HCCs 81-84) |
| RF= renal failure (HCC 131) |

1. Coefficients of HCCs 161 and 177 are constrained to be equal.

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
## Table 5-3

**Base HCC Model Estimated Excluding Diagnoses from RAPs and Clinically-Trained Non-Physicians**

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<th>Label</th>
<th>Parameter</th>
<th>Estimate</th>
<th>t-ratio</th>
<th>Parameter</th>
<th>Estimate</th>
<th>t-ratio</th>
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<td>Male, 0-34</td>
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<td>1,465</td>
<td>14.21</td>
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<tr>
<td>Male, 65-69</td>
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<td>34.23</td>
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<td>2,568</td>
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<td>34.74</td>
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<td>372</td>
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<td>5.53</td>
<td>638</td>
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<td>8.84</td>
<td>1,133</td>
<td>8.82</td>
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<tr>
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**Base HCC Model Estimated Excluding Diagnoses from RAPs and Clinically-Trained Non-Physicians**

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**Base HCC Model Estimated Excluding Diagnoses from RAPs and Clinically-Trained Non-Physicians**

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Table 5-3 (continued)

Base HCC Model Estimated Excluding Diagnoses from RAPs and Clinically-Trained Non-Physicians

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<td>DM *CVD</td>
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**NOTES:**

1 Source=1-5, Hosp=Hospital, MD=Physician. Also includes clinically-trained non-physicians.

2 Source=1-4a, Hosp=Hospital, MD=Physician, excluding diagnoses from RAPs and clinically-trained non-physicians.

DM= diabetes mellitus (HCCs 15-20)
CHF= congestive heart failure (HCC 80)
COPD= chronic obstructive pulmonary disease (HCC 108)
CVD= cerebrovascular disease (HCCs 95-103)
VD= vascular disease (HCCs 104-105)
CAD= coronary artery disease (HCCs 81-84)
RF= renal failure (HCC 131)

3 Coefficients of HCCs 161 and 177 are constrained to be equal.

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
Table 5-4

Predictive Power of Base Model Estimated with Alternative Diagnosis Sources

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<td>2. Hospital, physician (Base)</td>
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<td>3. Model 2 + Home Health Agency</td>
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<td>4. Model 3 + SNF, ASC, hospice</td>
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<td>6. Model 5 + lab, radiology/imaging clinics, misc. (ALL)</td>
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**NOTE:**
RAPs=Radiologists, Anesthesiologists, pathologists; SNF=Skilled Nursing Facility; ASC=Ambulatory Surgery Center; DME=Durable Medical Equipment.
From Tables 5-2 and 5-3.
Hospital/physician includes clinically trained non-physicians.

**SOURCE:** Health Economics Research, Inc.
Table 5-5
Predictive Ratios for Base HCC Model Estimated Using Alternative Sources of Diagnoses

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<th>Hosp, MD, no RAPs¹</th>
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Diagnoses Used for Estimation Added Cumulatively

¹ Hosp, MD, no RAPs
² Hosp, MD
³ HHA
⁴ SNF, ASC, HSP
⁵ DME
⁶ All Dxs
### Table 5-5 (continued)

#### Predictive Ratios for Base HCC Model Estimated Using Alternative Sources of Diagnoses

<table>
<thead>
<tr>
<th>Label</th>
<th>Hosp, MD no RAPs</th>
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Table 5-5 (continued)

Predictive Ratios for Base HCC Model Estimated Using Alternative Sources of Diagnoses

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<td>0.33</td>
<td>0.37</td>
<td>0.37</td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td>No DME spending 1996</td>
<td>1.54</td>
<td>1.54</td>
<td>1.53</td>
<td>1.53</td>
<td>1.53</td>
<td>1.53</td>
</tr>
<tr>
<td>DME spending &gt; 0 1996</td>
<td>0.40</td>
<td>0.41</td>
<td>0.42</td>
<td>0.42</td>
<td>0.43</td>
<td>0.42</td>
</tr>
<tr>
<td>DME spending &gt; 0: FIRST (LOWEST) QUINTILE, 1996</td>
<td>0.53</td>
<td>0.53</td>
<td>0.54</td>
<td>0.54</td>
<td>0.54</td>
<td>0.53</td>
</tr>
<tr>
<td>DME spending &gt; 0: SECOND QUINTILE, 1996</td>
<td>0.47</td>
<td>0.47</td>
<td>0.48</td>
<td>0.48</td>
<td>0.48</td>
<td>0.48</td>
</tr>
<tr>
<td>DME spending &gt; 0: MIDDLE QUINTILE, 1996</td>
<td>0.43</td>
<td>0.43</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
</tr>
<tr>
<td>DME spending &gt; 0: FOURTH QUINTILE, 1996</td>
<td>0.39</td>
<td>0.39</td>
<td>0.41</td>
<td>0.41</td>
<td>0.41</td>
<td>0.41</td>
</tr>
<tr>
<td>DME spending &gt; 0: FIFTH (HIGHEST) QUINTILE, 1996</td>
<td>0.32</td>
<td>0.32</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>DME spending &gt; 0: top 10% of DME spending 1996</td>
<td>0.29</td>
<td>0.29</td>
<td>0.32</td>
<td>0.32</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>DME spending &gt; 0: top 5% of DME spending 1996</td>
<td>0.26</td>
<td>0.26</td>
<td>0.29</td>
<td>0.29</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>No DME spending 1997</td>
<td>1.09</td>
<td>1.09</td>
<td>1.08</td>
<td>1.08</td>
<td>1.06</td>
<td>1.06</td>
</tr>
<tr>
<td>DME spending &gt; 0 1996</td>
<td>0.81</td>
<td>0.82</td>
<td>0.84</td>
<td>0.84</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>DME spending &gt; 0: FIRST (LOWEST) QUINTILE, 1996</td>
<td>0.93</td>
<td>0.94</td>
<td>0.95</td>
<td>0.95</td>
<td>0.97</td>
<td>0.97</td>
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<tr>
<td>DME spending &gt; 0: SECOND QUINTILE, 1996</td>
<td>0.89</td>
<td>0.89</td>
<td>0.91</td>
<td>0.91</td>
<td>0.93</td>
<td>0.93</td>
</tr>
<tr>
<td>DME spending &gt; 0: MIDDLE QUINTILE, 1996</td>
<td>0.88</td>
<td>0.89</td>
<td>0.91</td>
<td>0.91</td>
<td>0.94</td>
<td>0.94</td>
</tr>
<tr>
<td>DME spending &gt; 0: FOURTH QUINTILE, 1996</td>
<td>0.81</td>
<td>0.82</td>
<td>0.84</td>
<td>0.84</td>
<td>0.88</td>
<td>0.88</td>
</tr>
<tr>
<td>DME spending &gt; 0: FIFTH (HIGHEST) QUINTILE, 1996</td>
<td>0.66</td>
<td>0.65</td>
<td>0.68</td>
<td>0.68</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td>DME spending &gt; 0: top 10% of DME spending 1996</td>
<td>0.60</td>
<td>0.59</td>
<td>0.61</td>
<td>0.61</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>DME spending &gt; 0: top 5% of DME spending 1996</td>
<td>0.58</td>
<td>0.57</td>
<td>0.59</td>
<td>0.59</td>
<td>0.64</td>
<td>0.64</td>
</tr>
<tr>
<td>No DME spending 1997</td>
<td>1.41</td>
<td>1.41</td>
<td>1.40</td>
<td>1.40</td>
<td>1.39</td>
<td>1.39</td>
</tr>
<tr>
<td>DME spending &gt; 0 1997</td>
<td>0.57</td>
<td>0.57</td>
<td>0.58</td>
<td>0.58</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>DME spending &gt; 0: FIRST (LOWEST) QUINTILE, 1997</td>
<td>0.76</td>
<td>0.76</td>
<td>0.77</td>
<td>0.77</td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td>DME spending &gt; 0: SECOND QUINTILE, 1997</td>
<td>0.58</td>
<td>0.58</td>
<td>0.59</td>
<td>0.59</td>
<td>0.59</td>
<td>0.59</td>
</tr>
<tr>
<td>DME spending &gt; 0: MIDDLE QUINTILE, 1997</td>
<td>0.65</td>
<td>0.65</td>
<td>0.66</td>
<td>0.66</td>
<td>0.68</td>
<td>0.68</td>
</tr>
<tr>
<td>DME spending &gt; 0: FOURTH QUINTILE, 1997</td>
<td>0.54</td>
<td>0.54</td>
<td>0.55</td>
<td>0.55</td>
<td>0.57</td>
<td>0.57</td>
</tr>
</tbody>
</table>
Table 5-5 (continued)

Predictive Ratios for Base HCC Model Estimated Using Alternative Sources of Diagnoses

<table>
<thead>
<tr>
<th>Label</th>
<th>Diagnoses Used for Estimation Added Cumulatively</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hosp, MD, no RAPs</td>
</tr>
<tr>
<td>DME spending $&gt;$ 0: FIFTH (HIGHEST) QUINTILE, 1997</td>
<td>0.48</td>
</tr>
<tr>
<td>DME spending $&gt;$ 0: top 10% of DME spending 1997</td>
<td>0.51</td>
</tr>
<tr>
<td>DME spending $&gt;$ 0: top 5% of DME spending 1997</td>
<td>0.44</td>
</tr>
<tr>
<td>DME oxygen supplies/equipment (DME)</td>
<td>0.66</td>
</tr>
<tr>
<td>wheelchairs (DME)</td>
<td>0.68</td>
</tr>
<tr>
<td>walkers (DME)</td>
<td>0.83</td>
</tr>
<tr>
<td>1996 HOSP ADMISSIONS</td>
<td>1.03</td>
</tr>
<tr>
<td>2 1996 HOSP ADMISSIONS</td>
<td>1.01</td>
</tr>
<tr>
<td>3+ 1996 HOSP ADMISSIONS</td>
<td>0.97</td>
</tr>
<tr>
<td>3+ 1997 HOSP ADMISSIONS</td>
<td>0.82</td>
</tr>
<tr>
<td>0 1997 HOSP ADMISSIONS</td>
<td>3.54</td>
</tr>
<tr>
<td>1 1997 HOSP ADMISSIONS</td>
<td>0.56</td>
</tr>
<tr>
<td>2 1997 HOSP ADMISSIONS</td>
<td>0.34</td>
</tr>
<tr>
<td>3+ 1997 HOSP ADMISSIONS</td>
<td>0.24</td>
</tr>
</tbody>
</table>

NOTES:
1. Source=1-4a, Hosp=Hospital, MD=Physician, excluding diagnoses from RAPs and Clinically-Trained Non-Physicians.
2. Source=1-5, Hosp=Hospital, MD=Physician. Also includes Clinically-Trained Non-Physicians.
3. Source=1-5, 6b. HHA = Home Health Agency.
4. Source=1-6. SNF = Skilled Nursing Facility; HSP = Hospice; ASC = Ambulatory Surgery Center.
5. Source=1-6, 8. DME = Durable Medical Equipment.
7. Validation group diagnoses assigned using Source=1-6.

OUTPUT: D9p07ca.out, D9p07aa.out, D9p02vc.out, and D9p12ab.out

## Table 5-6

### Twenty Five Highest Frequency Home Health Diagnoses

<table>
<thead>
<tr>
<th>DXG</th>
<th>Label</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>91.01</td>
<td>essential hypertension</td>
<td>48,722</td>
</tr>
<tr>
<td>80.05</td>
<td>heart failure</td>
<td>24,322</td>
</tr>
<tr>
<td>43.05</td>
<td>osteoarthrosis, not specified to be of spine, hip, or knee</td>
<td>18,051</td>
</tr>
<tr>
<td>84.01</td>
<td>coronary atherosclerosis and other chronic ischemic heart disease</td>
<td>16,823</td>
</tr>
<tr>
<td>108.01</td>
<td>emphysema/chronic bronchitis</td>
<td>16,493</td>
</tr>
<tr>
<td>19.01</td>
<td>type II diabetes without complications</td>
<td>15,199</td>
</tr>
<tr>
<td>43.04</td>
<td>arthropathy/joint disorders, derangements, joint pain/stiffness, excluding gout</td>
<td>13,422</td>
</tr>
<tr>
<td>96.02</td>
<td>cerebrovascular accident, unspecified</td>
<td>13,288</td>
</tr>
<tr>
<td>135.01</td>
<td>cystitis, other urinary tract infections</td>
<td>10,409</td>
</tr>
<tr>
<td>19.02</td>
<td>type I diabetes without complications</td>
<td>10,241</td>
</tr>
<tr>
<td>92.02</td>
<td>atrial arrhythmia</td>
<td>9,755</td>
</tr>
<tr>
<td>36.03</td>
<td>stomach/intestinal disorders/symptoms, except obstruction, ulcer, and hemorrhage</td>
<td>9,613</td>
</tr>
<tr>
<td>134.02</td>
<td>incontinence/urethral discharge</td>
<td>9,579</td>
</tr>
<tr>
<td>47.01</td>
<td>iron deficiency and other/unspecified anemias</td>
<td>7,824</td>
</tr>
<tr>
<td>162.13</td>
<td>open wound, except eye and lower arm</td>
<td>7,755</td>
</tr>
<tr>
<td>113.02</td>
<td>other and unspecified pneumonia</td>
<td>7,599</td>
</tr>
<tr>
<td>167.02</td>
<td>other general symptoms</td>
<td>7,559</td>
</tr>
<tr>
<td>58.01</td>
<td>depression, excluding major depressive and bipolar disorders</td>
<td>6,879</td>
</tr>
<tr>
<td>23.01</td>
<td>disorders of fluid/electrolyte/acid-base balance, e.g., dehydration</td>
<td>6,793</td>
</tr>
<tr>
<td>83.02</td>
<td>angina pectoris</td>
<td>6,756</td>
</tr>
<tr>
<td>158.03</td>
<td>femoral (hip) fracture</td>
<td>6,663</td>
</tr>
<tr>
<td>105.05</td>
<td>unspecified peripheral vascular disease</td>
<td>5,873</td>
</tr>
<tr>
<td>24.04</td>
<td>thyroid disorders, except goiter and thyrotoxicosis</td>
<td>5,843</td>
</tr>
<tr>
<td>93.01</td>
<td>other conduction disorders/cardiac dysrhythmias</td>
<td>5,760</td>
</tr>
<tr>
<td>41.03</td>
<td>osteoporosis</td>
<td>5,526</td>
</tr>
</tbody>
</table>

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
### Table 5-7

**Twenty Five Highest Frequency DME Diagnoses**

<table>
<thead>
<tr>
<th>DXG</th>
<th>Label</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>108.01</td>
<td>emphysema/chronic bronchitis</td>
<td>32,229</td>
</tr>
<tr>
<td>43.05</td>
<td>osteoarthritis, not specified to be of spine, hip, or knee</td>
<td>18,172</td>
</tr>
<tr>
<td>43.04</td>
<td>arthropathy/joint disorders, derangements, joint pain/stiffness, excluding gou</td>
<td>16,548</td>
</tr>
<tr>
<td>19.02</td>
<td>type I diabetes without complications</td>
<td>15,324</td>
</tr>
<tr>
<td>80.05</td>
<td>heart failure</td>
<td>14,722</td>
</tr>
<tr>
<td>96.02</td>
<td>cerebrovascular accident, unspecified</td>
<td>13,896</td>
</tr>
<tr>
<td>19.01</td>
<td>type II diabetes without complications</td>
<td>12,984</td>
</tr>
<tr>
<td>43.08</td>
<td>disorders of soft tissue (e.g., tendonitis, bursitis, muscle disorders)</td>
<td>8,133</td>
</tr>
<tr>
<td>176.01</td>
<td>artificial opening of gastrointestinal tract status/complications</td>
<td>7,353</td>
</tr>
<tr>
<td>148.01</td>
<td>decubitus ulcer of skin</td>
<td>7,132</td>
</tr>
<tr>
<td>134.02</td>
<td>incontinence/urethral discharge</td>
<td>6,964</td>
</tr>
<tr>
<td>167.02</td>
<td>other general symptoms</td>
<td>6,931</td>
</tr>
<tr>
<td>158.03</td>
<td>femoral (hip) fracture</td>
<td>6,909</td>
</tr>
<tr>
<td>91.01</td>
<td>essential hypertension</td>
<td>6,434</td>
</tr>
<tr>
<td>110.01</td>
<td>asthma, except chronic obstructive</td>
<td>6,365</td>
</tr>
<tr>
<td>10.05</td>
<td>breast cancer, age 45+</td>
<td>6,191</td>
</tr>
<tr>
<td>43.07</td>
<td>nonspecific backache and other back/neck pain/disorders</td>
<td>5,946</td>
</tr>
<tr>
<td>162.06</td>
<td>fracture of hand/wrist/lower arm</td>
<td>5,133</td>
</tr>
<tr>
<td>179.03</td>
<td>joint replacement</td>
<td>4,909</td>
</tr>
<tr>
<td>162.12</td>
<td>sprains</td>
<td>4,513</td>
</tr>
<tr>
<td>161.01</td>
<td>traumatic amputation of leg/arm/hand/foot/toe, compl reattached body part</td>
<td>4,213</td>
</tr>
<tr>
<td>84.01</td>
<td>coronary atherosclerosis and other chronic ischemic heart disease</td>
<td>4,200</td>
</tr>
<tr>
<td>100.01</td>
<td>hemiplegia and hemiparesis</td>
<td>3,345</td>
</tr>
<tr>
<td>39.02</td>
<td>intervertebral disc disorders (herniated, prolapsed, degenerated disc)</td>
<td>3,202</td>
</tr>
<tr>
<td>40.02</td>
<td>osteoarthritis of lower leg (knee)</td>
<td>3,196</td>
</tr>
</tbody>
</table>

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
### Table 5-8

Aggregate Effect of Including and Omitting Various Sources of Diagnoses on Predicted Payments

Prospective Payment Medicare Model (N = 1,394,701)

<table>
<thead>
<tr>
<th>Simulation Run</th>
<th>Source Values Used</th>
<th>Description</th>
<th>Predicted Payments</th>
<th>Ratio of Current Run Prediction to Base Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1, 2, 3, 4, 5</td>
<td>Base Model</td>
<td>$5,314</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictions While Including Diagnoses from Further Sources</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1, 2, 3, 4, 5, 6b</td>
<td>Run 1 plus Home Health Agency</td>
<td>5,386</td>
<td>1.01</td>
</tr>
<tr>
<td>3</td>
<td>1, 2, 3, 4, 5, 6</td>
<td>Run 2 plus Skilled Nursing Facilities/and Ambulatory Surgery Centers</td>
<td>5,397</td>
<td>1.02</td>
</tr>
<tr>
<td>4</td>
<td>1, 2, 3, 4, 5, 6, 8</td>
<td>Run 3 plus Medical Supplies/DME</td>
<td>5,519</td>
<td>1.04</td>
</tr>
<tr>
<td>5</td>
<td>All Sources, 1-9</td>
<td>All diagnoses</td>
<td>5,660</td>
<td>1.07</td>
</tr>
<tr>
<td>Predictions While Omitting Diagnoses from Various Sources</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1, 2, 3, 4</td>
<td>Run 1 minus clinically trained non-MDs</td>
<td>5,198</td>
<td>0.98</td>
</tr>
<tr>
<td>7</td>
<td>1, 2, 3</td>
<td>Run 6 minus all MDs</td>
<td>3,682</td>
<td>0.69</td>
</tr>
<tr>
<td>8</td>
<td>1, 2</td>
<td>Run 7 minus hospital OPD</td>
<td>3,133</td>
<td>0.59</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>Run 8 minus inpatient secondary</td>
<td>2,560</td>
<td>0.48</td>
</tr>
<tr>
<td>10</td>
<td>None</td>
<td>No diagnoses used</td>
<td>2,288</td>
<td>0.43</td>
</tr>
</tbody>
</table>

**Computer Output:** "D9pr13aa.out.

**SOURCE:** Healthy Economics Research, Inc. analysis of 1996/1997 Medicare data.
### Table 5-9

#### Detailed Effects of Including and Omitting Sources of Diagnoses on Predicted Payments by Validation Group

**Prospective Payment Medicare Model (N = 1,394,701)**

#### Ratio of Simulation Run Prediction to Base Model Prediction:

<table>
<thead>
<tr>
<th>OBS</th>
<th>Validation Group name</th>
<th>Average Actual Payment</th>
<th>Base Model SOURCE 1-5</th>
<th>Base +HHA</th>
<th>+SNF+ASC+DME</th>
<th>ALL</th>
<th>Including Diagnoses from Further Sources 1-5, 1-6, 1-8*** 1-9</th>
<th>Omitting Diagnoses from Various Sources 1-4, 1-3, 1-2, 1-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ALL ENROLLEES</td>
<td>$5,314</td>
<td>1.00</td>
<td>1.01</td>
<td>1.02</td>
<td>1.07</td>
<td>0.98</td>
<td>0.69</td>
</tr>
<tr>
<td>2</td>
<td>AGED</td>
<td>5,413</td>
<td>1.00</td>
<td>1.02</td>
<td>1.04</td>
<td>1.06</td>
<td>0.98</td>
<td>0.70</td>
</tr>
<tr>
<td>3</td>
<td>DISABLED</td>
<td>4,559</td>
<td>1.00</td>
<td>1.01</td>
<td>1.01</td>
<td>1.05</td>
<td>1.08</td>
<td>0.66</td>
</tr>
<tr>
<td>4</td>
<td>FEMALE, &lt;=34</td>
<td>3,650</td>
<td>1.00</td>
<td>1.01</td>
<td>1.01</td>
<td>1.05</td>
<td>1.08</td>
<td>0.99</td>
</tr>
<tr>
<td>5</td>
<td>FEMALE, 35-44</td>
<td>4,236</td>
<td>1.00</td>
<td>1.01</td>
<td>1.01</td>
<td>1.04</td>
<td>1.07</td>
<td>0.98</td>
</tr>
<tr>
<td>6</td>
<td>FEMALE, 45-54</td>
<td>4,812</td>
<td>1.00</td>
<td>1.01</td>
<td>1.01</td>
<td>1.05</td>
<td>1.08</td>
<td>0.98</td>
</tr>
<tr>
<td>7</td>
<td>FEMALE, 55-59</td>
<td>5,339</td>
<td>1.00</td>
<td>1.01</td>
<td>1.02</td>
<td>1.05</td>
<td>1.08</td>
<td>0.98</td>
</tr>
<tr>
<td>8</td>
<td>FEMALE, 60-64</td>
<td>6,252</td>
<td>1.00</td>
<td>1.02</td>
<td>1.02</td>
<td>1.04</td>
<td>1.07</td>
<td>0.98</td>
</tr>
<tr>
<td>9</td>
<td>FEMALE, 65-69</td>
<td>3,582</td>
<td>1.00</td>
<td>1.01</td>
<td>1.01</td>
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<td>RACE = BLACK</td>
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<td>EVER DISABLED</td>
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<td>ANY 1996 CHRONIC CONDITION</td>
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<td>ALCOHOL / DRUG DEPENDENCE</td>
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<td>1.04</td>
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<td>BENIGN/UNSPECIFIED HYPERTENSION</td>
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<td>37</td>
<td>DIABETES WITH COMPLICATIONS</td>
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<td>1.02</td>
<td>1.04</td>
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<td>HEART FAILURE / CARDIOMYOPATHY</td>
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<td>1.02</td>
<td>1.02</td>
<td>1.04</td>
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<td>ACUTE MYOCARDIAL INFARCTION</td>
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<td>1.02</td>
<td>1.04</td>
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Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: 5-37
### Table 5-9 (continued)

**Detailed Effects of Including and Omitting Sources of Diagnoses on Predicted Payments by Validation Group**

Prospective Payment Medicare Model (N = 1,394,701)

<table>
<thead>
<tr>
<th>OBS</th>
<th>Validation Group Name</th>
<th>Average Base Model</th>
<th>Base Model Prediction to Base Model Prediction:</th>
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<td>SOURCE 1-5</td>
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<td>COLORECTAL CANCER</td>
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<td>BREAST CANCER</td>
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<td>LUNG/PANCREAS CANCER</td>
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<td>INTRACEREBRAL HEMORRHAGE</td>
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<td>DM<em>CHF</em>RF</td>
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<td>FIRST (LOWEST) QUINTILE, 1996 EXPEND</td>
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<td>MIDDLE QUINTILE, 1996 EXPEND</td>
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<td>FOURTH QUINTILE, 1996 EXPEND</td>
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<td>63</td>
<td>FIFTH (HIGHEST) QUINTILE, 1996 EXPEND</td>
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<td>Top 1 percent 1996</td>
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<td>SECOND QUINTILE, 1997 EXPEND</td>
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<td>FIFTH (HIGHEST) QUINTILE, 1997 EXPEND</td>
<td>23,334</td>
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<td>72</td>
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<td>HHA spending &gt;0 FIRST (LOWEST) QUINTILE, 1996</td>
<td>10,029</td>
<td>1.00 1.05 1.05 1.08 1.10</td>
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<td>74</td>
<td>HHA spending &gt;0 SECOND QUINTILE, 1996</td>
<td>10,626</td>
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<td>HHA spending &gt;0 top 5% of HHA spending 1996</td>
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### Ratio of Simulation Run Prediction to Base Model Prediction:

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<th>Omitting Diagnoses from Various Sources</th>
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Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: 5-38
Table 5-9 (continued)
Detailed Effects of Including and Omitting Sources of Diagnoses on Predicted Payments by Validation Group
Prospective Payment Medicare Model (N = 1,394,701)

Ratio of Simulation Run Prediction to Base Model Prediction:
Including Diagnoses from Further Sources Omitting Diagnoses from Various Sources

| OBS | Validation Group name                  | Average Actual Base Model Payment | Base +HHA +SNF+ASC+DME | 1-5 | 1-6 | 1-6, 8*** | 1-9 | 6-10 | 1-4 | 1-3 | 1-2 | 1-9 | 6-10 |
|-----|----------------------------------------|-----------------------------------|------------------------|-----|-----|---------|-----|-----|-----|-----|-----|-----|-----|-----|
| 84  | HHA spending > 0: MIDDLE QUINTILE, 1997| 20,778                            | 1.00                   | 1.03 | 1.04 | 1.07 | 1.09|     |     |     |     |     |     |     |
| 85  | HHA spending > 0: FOURTH QUINTILE, 1997| 25,865                            | 1.00                   | 1.05 | 1.05 | 1.09 | 1.11|     |     |     |     |     |     |     |
| 86  | HHA spending > 0: FIFTH (HIGHEST) QUINTILE, 1997| 37,205                            | 1.00                   | 1.09 | 1.09 | 1.15 | 1.17|     |     |     |     |     |     |     |
| 87  | HHA spending > 0: top 10% of HHA spending, 1997| 43,641                            | 1.10                   | 1.10 | 1.10 | 1.17 | 1.19|     |     |     |     |     |     |     |
| 88  | HHA spending > 0: top 5% of HHA spending, 1997| 51,024                            | 1.11                   | 1.11 | 1.19 | 1.21|     |     |     |     |     |     |     |     |
| 89  | No DME spending, 1996                  | 4,213                             | 1.01                   | 1.01 | 1.01 | 1.04 | 1.04|     |     |     |     |     |     |     |
| 90  | DME spending > 0, 1996                 | 11,365                            | 1.03                   | 1.03 | 1.03 | 1.10 | 1.13|     |     |     |     |     |     |     |
| 91  | DME spending > 0: FIRST (LOWEST) QUINTILE, 1996| 7,663                             | 1.00                   | 1.02 | 1.02 | 1.07 | 1.09|     |     |     |     |     |     |     |
| 92  | DME spending > 0: SECOND QUINTILE, 1996| 9,527                             | 1.03                   | 1.03 | 1.03 | 1.08 | 1.11|     |     |     |     |     |     |     |
| 93  | DME spending > 0: MIDDLE QUINTILE, 1996| 9,730                             | 1.03                   | 1.03 | 1.03 | 1.10 | 1.13|     |     |     |     |     |     |     |
| 94  | DME spending > 0: FOURTH QUINTILE, 1996| 12,711                            | 1.03                   | 1.04 | 1.04 | 1.12 | 1.14|     |     |     |     |     |     |     |
| 95  | DME spending > 0: FIFTH (HIGHEST) QUINTILE, 1996| 19,087                            | 1.04                   | 1.04 | 1.04 | 1.14 | 1.16|     |     |     |     |     |     |     |
| 96  | DME spending > 0: top 10% of DME spending, 1996| 20,944                            | 1.04                   | 1.04 | 1.04 | 1.15 | 1.17|     |     |     |     |     |     |     |
| 97  | DME spending > 0: top 5% of DME spending, 1996| 24,313                            | 1.05                   | 1.05 | 1.05 | 1.16 | 1.19|     |     |     |     |     |     |     |
| 98  | No DME spending, 1997                  | 3,291                             | 1.01                   | 1.01 | 1.01 | 1.02 | 1.05|     |     |     |     |     |     |     |
| 99  | DME spending > 0, 1997                 | 14,729                            | 1.03                   | 1.03 | 1.03 | 1.08 | 1.11|     |     |     |     |     |     |     |
| 100 | DME spending > 0: FIRST (LOWEST) QUINTILE, 1997| 8,504                             | 1.00                   | 1.02 | 1.02 | 1.05 | 1.08|     |     |     |     |     |     |     |
| 101 | DME spending > 0: SECOND QUINTILE, 1997| 12,486                            | 1.02                   | 1.02 | 1.02 | 1.06 | 1.09|     |     |     |     |     |     |     |
| 102 | DME spending > 0: MIDDLE QUINTILE, 1997| 12,054                            | 1.02                   | 1.03 | 1.03 | 1.10 | 1.12|     |     |     |     |     |     |     |
| 103 | DME spending > 0: FOURTH QUINTILE, 1997| 17,085                            | 1.03                   | 1.03 | 1.03 | 1.10 | 1.12|     |     |     |     |     |     |     |
| 104 | DME spending > 0: FIFTH (HIGHEST) QUINTILE, 1997| 24,451                            | 1.03                   | 1.04 | 1.04 | 1.11 | 1.13|     |     |     |     |     |     |     |
| 105 | DME spending > 0: top 10% of DME spending, 1997| 24,551                            | 1.04                   | 1.04 | 1.04 | 1.12 | 1.14|     |     |     |     |     |     |     |
| 106 | DME spending > 0: top 5% of DME spending, 1997| 30,535                            | 1.04                   | 1.04 | 1.04 | 1.12 | 1.15|     |     |     |     |     |     |     |
| 107 | oxygen supplies/equipment (DME)       | 18,910                            | 1.03                   | 1.03 | 1.03 | 1.11 | 1.13|     |     |     |     |     |     |     |
| 108 | wheelchairs (DME)                    | 12,258                            | 1.06                   | 1.06 | 1.06 | 1.17 | 1.19|     |     |     |     |     |     |     |
| 109 | walkers (DME)                         | 13,327                            | 1.03                   | 1.04 | 1.08 | 1.10|     |     |     |     |     |     |     |     |
| 110 | 0 1996 HOSP ADMISSIONS                | 3,960                             | 1.01                   | 1.01 | 1.01 | 1.03 | 1.06|     |     |     |     |     |     |     |
| 111 | 1 1996 HOSP ADMISSIONS                | 8,887                             | 1.02                   | 1.02 | 1.02 | 1.05 | 1.07|     |     |     |     |     |     |     |
| 112 | 2 1996 HOSP ADMISSIONS                | 12,826                            | 1.02                   | 1.02 | 1.02 | 1.05 | 1.07|     |     |     |     |     |     |     |
| 113 | 3+ 1996 HOSP ADMISSIONS               | 21,536                            | 1.02                   | 1.02 | 1.02 | 1.05 | 1.07|     |     |     |     |     |     |     |
| 114 | 0 1997 HOSP ADMISSIONS                | 1,300                             | 1.01                   | 1.01 | 1.01 | 1.03 | 1.06|     |     |     |     |     |     |     |
| 115 | 1 1997 HOSP ADMISSIONS                | 12,619                            | 1.02                   | 1.02 | 1.02 | 1.05 | 1.07|     |     |     |     |     |     |     |
| 116 | 2 1997 HOSP ADMISSIONS                | 25,258                            | 1.02                   | 1.02 | 1.02 | 1.05 | 1.08|     |     |     |     |     |     |     |
| 117 | 3+ 1997 HOSP ADMISSIONS               | 45,258                            | 1.02                   | 1.02 | 1.02 | 1.05 | 1.08|     |     |     |     |     |     |     |

NOTES:
Source 1 from the computer output "D9pr13aa.prt"
Source 0 from the computer output "D9pr13ca.prt"


Health Economics Research, Inc.
DCG/HCC Models for Medicare Risk Adjustment: 5-39
Durable medical equipment (DME) is a Medicare-covered benefit. Medicare-covered DME is heterogeneous, but several types of DME may be useful in identifying beneficiaries whose high expenditures are not fully captured by diagnoses. For example, some types of DME are mobility aids (e.g., wheelchairs, walkers), and are utilized by beneficiaries who are functionally impaired. Expenditures associated with functional impairment are not fully captured by diagnoses. This was shown in Chapter 4 by the underprediction by the base prospective risk adjustment model of total expenditures of beneficiaries utilizing DME. It was also shown in Pope et al., 1998 that diagnosis-based models underpredict for groups with multiple limitations in activities of daily living as measured using survey responses. In this chapter we examine whether DME utilization can be used to better predict the costs of functionally impaired beneficiaries, supplementing the predictive power of diagnosis-based risk adjustment models.

A potential advantage of using DME instead of survey based measures to identify functionally-impaired beneficiaries is that DME use may be available in the information systems of most Medicare+Choice plans. Thus, the need for expensive and burdensome surveys to assess the functional status of Medicare+Choice enrollees would be avoided. Moreover, survey functional status measures are only available for a small sample of each plan's enrollees, whereas automated DME records are potentially available for all
utilizing enrollees. Finally, the incremental total expenditures associated with DME use can be accurately calibrated with large samples of Medicare fee-for-service enrollees, such as the 5 percent sample used in this report.

Balancing these advantages are disadvantages of DME as a risk adjuster. The largest concern is that incentives would be established for M+C plans to inappropriately increase DME utilization to generate additional risk-adjusted payments.\(^1\) For example, suppose a wheelchair can be supplied to a M+C enrollee at a cost of $1,500, and that wheelchair use triggers an additional $4,500 Medicare payment to a health plan per beneficiary. Then the health plan makes a "profit" of $3,000 on each beneficiary supplied with a wheelchair. HCFA could establish and audit strict guidelines for appropriateness of DME utilization, but this would be expensive and burdensome on HCFA and on plans. Disputes might arise over "borderline" cases.

A second concern is the cost of collecting data on DME utilization. Aside from concerns about inappropriate DME use, M+C plans and HCFA would have to establish DME data collection and verification systems such as are currently used in FFS Medicare. This would increase costs to HCFA and M+C plans. Another problem is that Medicare claims or encounter data may not provide a complete profile of DME use. For example, some DME used by Medicare beneficiaries may be paid for by other insurers or government programs such as Medicaid or the Veteran Administration, or may be paid

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\(^1\) Of course, under diagnosis-based payments, plans have incentives to inappropriately record reimbursable diagnoses. This may be less costly than providing inappropriate DME.
for out-of-pocket by beneficiaries. Similarly, one base year may not capture all DME utilization. Most “big ticket” DME items are “durable”, and usage may not appear in the claims record every year. Associated supplies may appear more frequently in claims, but they may be easier for HMOs to “game” by overproviding than the expensive big-ticket items (wheelchairs, oxygen machines, etc.) In many instances it is difficult to distinguish short-term from long-term use of DME. For example, a beneficiary may use a wheelchair after leaving the hospital for an operation. But when recovered, the beneficiary would no longer need the wheelchair. Thus, wheelchair use may confound those who are temporarily disabled with those who are long-term disabled. Finally, managed care use of DME may differ from FFS usage, because M+C plans do not have the same DME reimbursement criteria as the FFS sector.

In the remainder of this chapter we evaluate how much the predictive accuracy of our base risk adjustment model can be augmented by incorporating DME. We also briefly consider the contribution to expenditure prediction in the 1996/97 dataset of the "life sustaining procedures" (e.g., organ transplants) that we developed in previous projects (Ellis et al., 1996; Pope et al., 1998). We begin by providing basic descriptive statistics on DME and procedure groups. Then we discuss the integration of selected DME and procedures into our clinical classification system. Estimates of alternative risk adjustment models adding DME and procedures to our base model follow. Finally, we

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2 To the extent that DME use predicts only DME costs, the loss of information due to use of other insurers/providers is not of consequence. To the extent that DME use predicts non-DME costs, the loss is problematic. The same problem can exist for diagnoses if there is high use of the VA or Department of Defense systems, although diagnoses are more likely to be replicated across sites of care.
evaluate the gains in predictive accuracy for individuals and groups when DME and procedures are additional risk adjusters.

6.1 Durable Medical Equipment and Procedure Groups

HCFA staff provided us with 56 DME "policy groups". Frequencies of these DME policy groups for our 1996 base year, and mean and levels of dispersion for 1997 annualized spending are shown in Table 6-1. These policy groups were developed by HCFA's SADMERC (Statistical Analysis Durable Medical Equipment Regional Carrier) for analysis of coverage of related equipment and supplies. The SADMERC receives claims from the insurance carriers that process and pay Medicare DME claims, and use the groups as an aid to help refine coverage policy. The policy groups are the basic "building blocks" for all our DME analyses.

Descriptive statistics for the DME policy groups are shown in Table 6-1. The most frequent DME item utilized is "wheelchairs", which was utilized by 37,573 beneficiaries, or 2.7 percent of our prospective sample, in 1996. Other frequently utilized types of DME include walkers, oxygen supplies and equipment, nebulizers and related drug administration devices, glucose monitors, hospital beds and accessories, and commodes/bedpans/urinals. Although not as common, the types of DME associated with the highest following year expenditures include parenteral and enteral nutrition, ventilators, patient lifts, suction pumps, support surfaces, and tracheostomy supplies.

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3 “Utilized” includes “purchased” and “rented” or “leased”. Medicare will pay for no more than 15 months rental according to the HCFA website.
Chapter 6 Evaluation of Durable Medical Equipment as a Risk Adjuster

Descriptive statistics for our 14 life sustaining procedure groups are shown in Table 6-2 (see Ellis et al., 1996 and Pope et al., 1998 for further discussion of our procedure groups). Six of the 14 groups are organ transplants. These procedure groups are defined by CPT-4 procedure codes, and are identified in the Medicare Part B physician/supplier Standard Analytic File. Many of these procedures, especially the transplants, are quite rare in the Medicare population. For example, only 2 beneficiaries receiving lung transplants are identified in our 5 percent Medicare sample. The more common procedure groups are chemo- and radiotherapy, and gastrotomy/enterostomy. While rare, the life-sustaining procedures identify beneficiaries with high Medicare expenditures in the following year. For example, the mean 1997 expenditures of the 875 beneficiaries with a tracheostomy procedure code in 1996 are $48,600.

6.2 Integrating DME and Procedures into Diagnostic Classification

With guidance from our clinician coauthors, we selected DME types to add to our diagnostic classification (see Chapter 2). The criteria for selecting DME types to add were:

- DME types that identify high-expenditure beneficiaries, especially beneficiaries whose high expenditures are not predicted well by diagnostic-based models. This was determined by empirical regression analysis as reported later in this chapter.
- DME types that identify functionally impaired or limited beneficiaries. This was determined by clinical judgment.
- DME types that are utilized by a sufficiently large number of Medicare beneficiaries that incremental next year total expenditures associated with them can be accurately estimated. This was determined by empirical analysis.
• DME types that are less subject to incentive problems such as inappropriate oversupply. For this reason, we avoided inexpensive types of DME, such as inexpensive supplies or disposable items.

Application of these criteria to the 56 original DME policy groups resulted in 16 new “DME-DxGroups” being selected for consideration in our DCG/HCC model. For example, these DME-DxGroup include “185.01 oxygen supplies/equipment,” “187.01 hospital beds,” and “188.01 wheelchairs.” Beneficiaries were assigned to each of the DME-DxGroups based on DME claims utilization in the base year (1996). All 16 DME-DxGroups are based directly on a corresponding HCFA SADMERC DME policy group, with no changes in included HCPCs codes.4

Of these 16 new DME-DxGroups, twelve were aggregated into five DME-based HCCs. Six were classified into HCCs that had already been defined using diagnostic information. Altogether 11 HCCs are affected by the inclusion of DME information.

The five clusters of DME-DxGroups assigned to DME-based HCCs are shown in Table 6-3. These new HCCs are grouped into two "hierarchies". The first is "respiratory therapy", which includes the two HCCs "Oxygen" and "CPAP/IPPB/Nebulizers". The first HCC, "Oxygen", is ranked above the second, and HCC 77 "Respiratory Dependence/Tracheostomy Status" (not shown in Table 6-3) is ranked above both these HCCs.5

4 Further refinement of the HCFA DME policy groups to exclude inexpensive equipment and supplies, and focus on “big ticket” items, would be desirable, but was not possible with the resources available to this project.

5 HCC 77 includes diagnosis codes (V-codes), procedure codes, and DME codes (ventilator). See discussion later in this section.
hierarchy) shown in Table 6-3. The respiratory therapy and mobility hierarchies are additive to each other.

The six DME-DxGroups that are closely related to HCCs already defined based on ICD-9-CM "V codes" were simply grouped into existing HCCs. The DME-DxGroups that were incorporated into existing diagnosis-code-based HCCs are shown in Table 6-4. These HCCs reflect both diagnostic and DME information, and no changes in the base model hierarchies or HCC labels were made for these HCCs.

Table 6-5 shows the HCC assignments of the 14 procedure-based DxGroups. Five of the six transplant procedure groups are assigned to the only HCC based strictly on procedures, HCC 173 Major Organ Transplant. (The kidney transplant DxGroup 128.02 is assigned to HCC 128 Kidney Transplant, which also includes the V code for kidney transplant status.) All other procedure-based DxGroups were assigned to existing diagnosis-code-based HCCs.

### 6.3 Analysis of Predictive Power

Our multiple regression analysis of DME predictive power is presented in Tables 6-6, 6-7, and 6-8. Table 6-6 shows the detailed regression coefficient estimates. Table 6-7 abstracts from Table 6-6 the predictive power (R-square) of alternative models. Table 6-8 abstracts from Table 6-6 estimated incremental DME payments (coefficients) with comparisons to other estimated coefficients. Table 6-9 shows the predictive accuracy of alternative models for subgroups of Medicare beneficiaries. The models we compare in this analysis are:
• the base, diagnoses-only model (Model 5 of Table 4-2);
• the base model plus all HCFA DME policy groups;
• the base model plus our selected DME groups as described in Section 6.2; and
• the base model plus our selected DME groups and our selected procedure groups.

Table 6-7 shows that DME adds considerably to base model explanatory power. The R-square rises from 11.15 percent to 12.46 percent when all HCFA DME policy groups are added to the model. When DME is limited to the 16 of 56 categories that we selected for incorporation into our diagnostic classification (see the preceding section), the R-square falls only slightly, from 12.46 percent to 12.23 percent. Most of DME's explanatory power is contained in a relatively small number of DME types. Adding our procedure groups raises predictive power only very slightly, from 12.23 percent to 12.28 percent. Although they identify high cost beneficiaries, the procedures are too infrequent to significantly raise predictive power.

In Table 6-6 (Model 2), many of the HCFA DME policy groups have large, statistically significant coefficients. But only a relatively small proportion—primarily the 16 chosen for incorporation into our classification system—appear to have really substantial impacts on predictive power (as judged by their coefficient magnitudes and t-statistics). Comparing Models 1 and 2, it is interesting that adding DME reduces the

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6 Note that the procedure groups with the greatest frequency, chemo- and radiotherapy, are not included in the payment version of our model, which limits the gain in explanatory power from adding the procedure groups. These procedures are not included in the payment version because the HCCs that contain them are excluded from the payment version of the model (see Chapter 2).
coefficients of certain diagnoses quite a lot: for example chronic obstructive pulmonary disease (COPD), hip fracture, neurological problems, lower limb amputation status, and diabetes. For example, the coefficient of HCC 158 "Hip Fracture/Dislocation" is reduced from $1,050 to $250 when DME is added. Beneficiaries with these diagnoses are clearly the heaviest users of DME, and when DME is added to the model, some of the predicted payments associated with these diagnoses are shifted to the DME categories. Since there is an overall gain in explanatory power, shifting predicted payments from one risk adjuster to another is not all that is occurring—DME is adding explanatory power by identifying more severely impaired/ill beneficiaries, or beneficiaries without appropriate diagnosis codes.

Table 6-8 shows incremental payments (coefficients) associated with selected DME-HCCs as estimated in Model 3. The DME coefficients are quite large.\(^7\) Utilization of patient lifts in the base year is associated with about the same incremental expenditures as a base year diagnosis of metastatic cancer. Use of a walker is associated with larger incremental expenditures than COPD, and much larger expenditures than hip fracture. The DME coefficients are so large absolutely, relative to the cost of the DME itself, and relative to the diagnosis coefficients, that we have substantial concern about including DME in a payment model. The large incremental payments associated with DME would give M+C plans strong incentives to inappropriately increase DME utilization.

\(^7\) Note from Table 6-1 that since the person years for 1997 are similar to the number of people, these high predicted expenses do not seem to be explained by high rates of mortality among DME users.
Not surprisingly, Table 6-9 shows that incorporating DME (compare columns 1 and 2) substantially improves predictive accuracy for groups defined by DME spending or utilization. For example, 96 percent versus 82 percent of the mean total expenditures of prior year DME utilizers are predicted when DME is included versus not. Predictive accuracy is also improved moderately for home health utilizers, as there plausibly is a correlation between DME and home health use. Eighty two percent of mean total expenditures are predicted for beneficiaries with any prior year home health use with DME included versus 75 percent without DME. Adding our procedure groups to the base plus DME model (compare columns 2 and 3 in Table 6-9) results in no detectable improvement in predictive accuracy.

Gains in predictive accuracy for other groups are detectable, but are not large. For example, the predictive ratio for those with 3 or more prior year hospital admissions rises from 82 percent to 84 percent. The predictive ratio for the 5th quintile of prior year total spending increases from 86 percent to 89 percent. These are not inconsequential improvements, but still fall far short of perfect prediction. Surprisingly, predictive accuracy for the diagnosis of arthritis is hardly improved at all.

Overall, adding DME as a risk adjuster does significantly improve predictive accuracy, especially for those utilizing Medicare DME and home health services, who may proxy to some extent for the functionally impaired. But the large incremental payments associated with DME utilization raise serious concerns about incentives to inappropriately provide DME to enrollees and thereby "game" the payment system.
Table 6-1
Descriptive Statistics by HCFA DME Policy Group

<table>
<thead>
<tr>
<th>DME Group</th>
<th>1996 Frequency</th>
<th>1997 Person Years</th>
<th>1997 Mean Expenditures</th>
<th>Std. Err. Mean</th>
<th>Std. Dev. Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast Prostheses</td>
<td>7,766</td>
<td>7,535</td>
<td>$5,244</td>
<td>$140</td>
<td>$12,140</td>
</tr>
<tr>
<td>Continuous Positive Airway Pressure System (CPAP)</td>
<td>3,683</td>
<td>3,515</td>
<td>10,471</td>
<td>372</td>
<td>22,057</td>
</tr>
<tr>
<td>CPM Device</td>
<td>1,058</td>
<td>1,041</td>
<td>5,322</td>
<td>283</td>
<td>9,142</td>
</tr>
<tr>
<td>Canes/Crutches</td>
<td>13,694</td>
<td>12,980</td>
<td>11,771</td>
<td>184</td>
<td>20,962</td>
</tr>
<tr>
<td>Commodities/Bed Pans/Urinals</td>
<td>18,608</td>
<td>16,831</td>
<td>16,017</td>
<td>191</td>
<td>24,723</td>
</tr>
<tr>
<td>Diabetic Shoes</td>
<td>2,649</td>
<td>2,495</td>
<td>16,450</td>
<td>559</td>
<td>27,035</td>
</tr>
<tr>
<td>Dialysis Supplies &amp; Equipment</td>
<td>354</td>
<td>331</td>
<td>19,262</td>
<td>1,775</td>
<td>22,285</td>
</tr>
<tr>
<td>Dynamic Splint</td>
<td>193</td>
<td>176</td>
<td>13,317</td>
<td>2,064</td>
<td>27,376</td>
</tr>
<tr>
<td>Enteral Nutrition</td>
<td>2,986</td>
<td>2,408</td>
<td>24,225</td>
<td>589</td>
<td>28,877</td>
</tr>
<tr>
<td>Epinephrine</td>
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<td>1</td>
<td>73,504</td>
<td>51,694</td>
<td>57,796</td>
</tr>
<tr>
<td>Eye Prostheses</td>
<td>727</td>
<td>699</td>
<td>7,520</td>
<td>730</td>
<td>19,297</td>
</tr>
<tr>
<td>Facial Prosthesies</td>
<td>4</td>
<td>4</td>
<td>13,392</td>
<td>5,413</td>
<td>10,247</td>
</tr>
<tr>
<td>Glucose Monitor</td>
<td>25,160</td>
<td>23,696</td>
<td>12,902</td>
<td>148</td>
<td>22,793</td>
</tr>
<tr>
<td>Heat/Cold Application</td>
<td>1,350</td>
<td>1,311</td>
<td>10,827</td>
<td>531</td>
<td>19,211</td>
</tr>
<tr>
<td>Hospital Bed/Accessories</td>
<td>21,571</td>
<td>18,858</td>
<td>19,895</td>
<td>191</td>
<td>26,279</td>
</tr>
<tr>
<td>Intermittent Positive Pressure Breathing System (IPPP)</td>
<td>171</td>
<td>159</td>
<td>22,319</td>
<td>2,302</td>
<td>29,026</td>
</tr>
<tr>
<td>Immunosuppressive Drugs</td>
<td>19</td>
<td>14</td>
<td>18,880</td>
<td>18,222</td>
<td>67,773</td>
</tr>
<tr>
<td>Impotence Aid</td>
<td>2,862</td>
<td>2,777</td>
<td>5,674</td>
<td>236</td>
<td>12,458</td>
</tr>
<tr>
<td>Infusion Pumps &amp; Related Drugs</td>
<td>1,057</td>
<td>910</td>
<td>22,669</td>
<td>962</td>
<td>29,001</td>
</tr>
<tr>
<td>Lenses</td>
<td>883</td>
<td>845</td>
<td>5,774</td>
<td>559</td>
<td>16,266</td>
</tr>
<tr>
<td>Lower Limb Orthoses</td>
<td>13,928</td>
<td>13,150</td>
<td>10,484</td>
<td>167</td>
<td>19,118</td>
</tr>
<tr>
<td>Lower Limb Prostheses</td>
<td>2,906</td>
<td>2,689</td>
<td>15,451</td>
<td>493</td>
<td>25,541</td>
</tr>
<tr>
<td>Nebulizers &amp; Related Drugs</td>
<td>22,402</td>
<td>20,325</td>
<td>16,530</td>
<td>180</td>
<td>25,624</td>
</tr>
<tr>
<td>Oral Anti-Cancer Drugs</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Oral Anti-Emetic Drugs</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Orthotic Footwear</td>
<td>1,478</td>
<td>1,422</td>
<td>10,270</td>
<td>465</td>
<td>17,539</td>
</tr>
<tr>
<td>Orthosis/Prosthesis Repair</td>
<td>1,330</td>
<td>1,262</td>
<td>10,841</td>
<td>588</td>
<td>20,870</td>
</tr>
<tr>
<td>Ostogenesys Stimulator</td>
<td>153</td>
<td>146</td>
<td>12,734</td>
<td>1,933</td>
<td>23,312</td>
</tr>
<tr>
<td>Ostomy Supplies</td>
<td>9,329</td>
<td>8,640</td>
<td>11,229</td>
<td>221</td>
<td>20,535</td>
</tr>
<tr>
<td>Other Neuromuscular Stimulators</td>
<td>593</td>
<td>571</td>
<td>10,689</td>
<td>828</td>
<td>19,801</td>
</tr>
<tr>
<td>Oxygen Supplies/Equipment</td>
<td>26,569</td>
<td>23,241</td>
<td>18,914</td>
<td>177</td>
<td>26,948</td>
</tr>
<tr>
<td>Power Operated Vehicle (POV)</td>
<td>505</td>
<td>472</td>
<td>17,215</td>
<td>1,294</td>
<td>28,107</td>
</tr>
<tr>
<td>Parenteral Nutrition</td>
<td>82</td>
<td>68</td>
<td>37,550</td>
<td>4,948</td>
<td>40,752</td>
</tr>
<tr>
<td>Patient Lift</td>
<td>2,370</td>
<td>2,052</td>
<td>26,501</td>
<td>606</td>
<td>27,453</td>
</tr>
<tr>
<td>Pneumatic Compression Device</td>
<td>468</td>
<td>457</td>
<td>15,781</td>
<td>1,155</td>
<td>24,143</td>
</tr>
<tr>
<td>Reimbursement/DMF</td>
<td>1,660</td>
<td>1,592</td>
<td>12,829</td>
<td>510</td>
<td>20,335</td>
</tr>
<tr>
<td>Respiratory Assist Device</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Seat Lift Mechanism</td>
<td>1,266</td>
<td>1,155</td>
<td>15,009</td>
<td>555</td>
<td>18,862</td>
</tr>
<tr>
<td>Spinal Orthoses</td>
<td>7,974</td>
<td>7,636</td>
<td>10,013</td>
<td>216</td>
<td>18,809</td>
</tr>
<tr>
<td>Suction Pump</td>
<td>1,434</td>
<td>1,175</td>
<td>26,860</td>
<td>1,001</td>
<td>34,308</td>
</tr>
<tr>
<td>Support Surfaces</td>
<td>5,477</td>
<td>4,638</td>
<td>24,469</td>
<td>410</td>
<td>27,903</td>
</tr>
<tr>
<td>Surgical Dressings</td>
<td>7,532</td>
<td>6,623</td>
<td>15,878</td>
<td>302</td>
<td>24,595</td>
</tr>
<tr>
<td>Transcutaneous Electrical Nerve Stimulators (TENS)</td>
<td>2,337</td>
<td>2,234</td>
<td>11,390</td>
<td>449</td>
<td>21,231</td>
</tr>
<tr>
<td>Tracheostomy Supplies</td>
<td>511</td>
<td>447</td>
<td>24,595</td>
<td>1,515</td>
<td>32,026</td>
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<td>555</td>
<td>9,470</td>
<td>752</td>
<td>17,711</td>
</tr>
<tr>
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<td>7,891</td>
<td>8,332</td>
<td>189</td>
<td>16,814</td>
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<tr>
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<td>6,889</td>
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<tr>
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<td>562</td>
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<td>1,424</td>
<td>33,748</td>
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<td>Voice Prostheses</td>
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<td>223</td>
<td>11,848</td>
<td>1,220</td>
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<tr>
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<td>28,579</td>
<td>26,352</td>
<td>13,327</td>
<td>140</td>
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</tr>
<tr>
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<td>17,288</td>
<td>137</td>
<td>25,160</td>
</tr>
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<td>22,998</td>
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<td>22,883</td>
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<td>70</td>
<td>17,173</td>
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NOTE: DME categories assigned from DME Standard Analytic File only.

OUTPUT: D9pr06a.out

### Table 6-2

Descriptive Statistics by Procedure Group (DXGs)

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<tr>
<th>DXG</th>
<th>Label</th>
<th>1996 Frequency</th>
<th>1997 Person Years</th>
<th>1997 Mean Expenditures</th>
<th>Std. Err. Mean</th>
<th>Std. Dev. of Variation</th>
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</thead>
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<td>tracheostomy (procedure)</td>
<td>875</td>
<td>662</td>
<td>$48,600</td>
<td>$3,814</td>
<td>202%</td>
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<tr>
<td>128.02</td>
<td>kidney transplant (procedure)</td>
<td>8</td>
<td>8</td>
<td>31,980</td>
<td>19,318</td>
<td>54,640</td>
</tr>
<tr>
<td>130.02</td>
<td>dialysis (procedure)</td>
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<td>488</td>
<td>42,921</td>
<td>3,799</td>
<td>83,950</td>
</tr>
<tr>
<td>173.01</td>
<td>lung transplant (procedure)</td>
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<td>2</td>
<td>14,248</td>
<td>14,212</td>
<td>20,099</td>
</tr>
<tr>
<td>173.02</td>
<td>heart transplant (procedure)</td>
<td>24</td>
<td>24</td>
<td>26,334</td>
<td>8,125</td>
<td>39,386</td>
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<tr>
<td>173.03</td>
<td>bone marrow transplant (procedure)</td>
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<td>9</td>
<td>31,604</td>
<td>11,501</td>
<td>34,822</td>
</tr>
<tr>
<td>173.04</td>
<td>liver transplant (procedure)</td>
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<td>14</td>
<td>17,379</td>
<td>9,413</td>
<td>35,532</td>
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<tr>
<td>173.05</td>
<td>pancreas transplant (procedure)</td>
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<tr>
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<td>793</td>
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<tr>
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<td>557</td>
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<td>1,585</td>
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<td>1,315</td>
<td>24,782</td>
<td>994</td>
<td>32,762</td>
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<tr>
<td>178.02</td>
<td>amputation, upper limb (procedure)</td>
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<td>10</td>
<td>11,153</td>
<td>4,938</td>
<td>15,419</td>
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<tr>
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<td>22,273</td>
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<td>181.02</td>
<td>chemotherapy (procedure)</td>
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<td>10,509</td>
<td>16,237</td>
<td>223</td>
<td>22,907</td>
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**OUTPUT:** D9pr04aa.out and D9pr04aa.ou2

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
<table>
<thead>
<tr>
<th>HCC</th>
<th>Dx Group</th>
<th>This HCC Excludes</th>
<th>Hierarchy</th>
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<tbody>
<tr>
<td>185</td>
<td>Oxygen&lt;sup&gt;1&lt;/sup&gt;</td>
<td>186</td>
<td>Respiratory Therapy 1</td>
</tr>
<tr>
<td></td>
<td>185.01 oxygen supplies/equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>186</td>
<td>CPAP/IPPB/Nebulizers&lt;sup&gt;1&lt;/sup&gt;</td>
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<td>Respiratory Therapy 2</td>
</tr>
<tr>
<td></td>
<td>186.01 nebulizers and related drugs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>186.02 continuous positive airway pressure system</td>
<td>188, 189</td>
<td>Mobility 1</td>
</tr>
<tr>
<td></td>
<td>186.03 intermittent positive pressure breathing system</td>
<td>189</td>
<td>Mobility 2</td>
</tr>
<tr>
<td>187</td>
<td>Patient Lifts, Power-Operated Vehicles, Beds</td>
<td></td>
<td>Mobility 3</td>
</tr>
<tr>
<td></td>
<td>187.01 hospital beds/accessories</td>
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<tr>
<td></td>
<td>187.02 patient lifts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>187.03 power operated vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>188</td>
<td>Wheelchairs, Commodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>188.01 wheelchairs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>188.02 commodes/bed pans/urinals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>189</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>189.01 walkers</td>
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</tbody>
</table>

<sup>1</sup> This HCC is excluded by HCC 77 Respiratory Dependence/Tracheotomy Status, which includes DME ventilators.

**SOURCE:** Health Economics Research, Inc.
### Table 6-4

**DME Groups Mapped Into Diagnosis-Based HCCs**

<table>
<thead>
<tr>
<th>DME Group</th>
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<tbody>
<tr>
<td>77.04 Ventilators</td>
<td>77 Respirator Dependence</td>
</tr>
<tr>
<td>130.03 Dialysis supplies and equipment</td>
<td>130 Dialysis Status</td>
</tr>
<tr>
<td>176.06 Enteral nutrition</td>
<td>176 Artificial Openings for Feeding and Elimination</td>
</tr>
<tr>
<td>176.07 Parenteral nutrition</td>
<td>176 Artificial Openings for Feeding and Elimination</td>
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<tr>
<td>177.03 Lower limb prostheses</td>
<td>177 Amputation Status, Lower Limb</td>
</tr>
<tr>
<td>178.03 Upper limb prostheses</td>
<td>178 Amputation Status, Upper Limb</td>
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</tbody>
</table>

**SOURCE:** Health Economics Research, Inc.
Table 6-5
Procedure Groups Mapped into HCCs

<table>
<thead>
<tr>
<th>Procedure Group</th>
<th>HCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>77.03 tracheostomy</td>
<td>77 Respirator Dependence/Tracheostomy</td>
</tr>
<tr>
<td>128.02 kidney transplant</td>
<td>128 Kidney Transplant</td>
</tr>
<tr>
<td>130.02 dialysis</td>
<td>130 Dialysis</td>
</tr>
<tr>
<td>173.01 lung transplant</td>
<td>173 Major Organ Transplant</td>
</tr>
<tr>
<td>173.02 heart transplant</td>
<td>173 Major Organ Transplant</td>
</tr>
<tr>
<td>173.03 bone marrow transplant</td>
<td>173 Major Organ Transplant</td>
</tr>
<tr>
<td>173.04 liver transplant</td>
<td>173 Major Organ Transplant</td>
</tr>
<tr>
<td>173.05 pancreas transplant</td>
<td>173 Major Organ Transplant</td>
</tr>
<tr>
<td>176.04 gastrostomy</td>
<td>176 Artificial Openings</td>
</tr>
<tr>
<td>176.05 enterostomy</td>
<td>176 Artificial Openings</td>
</tr>
<tr>
<td>177.02 amputation, lower limb</td>
<td>177 Amputation Status, Lower Limb</td>
</tr>
<tr>
<td>178.02 amputation, upper limb</td>
<td>177 Amputation Status, Upper Limb</td>
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<tr>
<td>180.02 radiation therapy</td>
<td>180 Radiation Therapy</td>
</tr>
<tr>
<td>181.02 chemotherapy</td>
<td>181 Chemotherapy</td>
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</table>

SOURCE: Health Economics Research, Inc.
Table 6-6
HCC Prospective Risk Adjustment Models with DME and Procedure Groups

<table>
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<tr>
<th>HCC Prospective Risk Adjustment Models</th>
<th>Base Model</th>
<th>All DME Groups</th>
<th>Selected DME groups</th>
<th>Selected DME Procs</th>
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<td>0.1115</td>
<td>0.1246</td>
<td>0.1223</td>
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<tr>
<td>Adjusted R-Square</td>
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<td>12,947</td>
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<tr>
<td>Model Parameters</td>
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<td>180</td>
<td>132</td>
<td>133</td>
</tr>
<tr>
<td>Computer Output:</td>
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<td>D9pr03f.out2</td>
<td>D9pr05a.prt</td>
<td>D9pr05a.prt</td>
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</tbody>
</table>

<table>
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<th>Parameter Estimate</th>
<th>t-ratio</th>
<th>Parameter Estimate</th>
<th>t-ratio</th>
<th>Parameter Estimate</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
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<td>$191</td>
<td>1.49</td>
<td>$183</td>
<td>1.43</td>
<td>$184</td>
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<td>307</td>
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<td>7.50</td>
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<td>7.54</td>
<td>628</td>
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<td>8.43</td>
<td>949</td>
<td>8.37</td>
</tr>
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<td>13.83</td>
<td>1,413</td>
<td>13.80</td>
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<td>35.48</td>
<td>1,509</td>
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<td>51.49</td>
<td>1,959</td>
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<td>3,039</td>
<td>56.12</td>
<td>3,045</td>
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<td>3,765</td>
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<td>4,352</td>
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<td>387</td>
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<td>2.51</td>
<td>402</td>
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<td>627</td>
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<tr>
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<td>59.39</td>
<td>2,090</td>
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</tr>
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Table 6-6 (Continued)
Table 6-6 (Continued)  
HCC Prospective Risk Adjustment Models with DME and Procedure Groups

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Health Economics Research, Inc.
DCG/HCC Models for Medicare Risk Adjustment: 6-18
Table 6-6 (Continued)

HCC Prospective Risk Adjustment Models with DME and Procedure Groups

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Health Economics Research, Inc.  
DCG/HCC Models for Medicare Risk Adjustment: 6-19
## Table 6-6 (Continued)

### HCC Prospective Risk Adjustment Models with DME and Procedure Groups

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**HCC Prospective Risk Adjustment Models with DME and Procedure Groups**

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Table 6-6 (Continued)

HCC Prospective Risk Adjustment Models with DME and Procedure Groups

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Health Economics Research, Inc.
Table 6-6 (Continued)

HCC Prospective Risk Adjustment Models with DME and Procedure Groups

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<td><em>Routinely Denied Items</em></td>
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</tr>
</tbody>
</table>

NOTES:
DM= diabetes mellitus (HCCs 15-20)
CHF= congestive heart failure (HCC 80)
COPD= chronic obstructive pulmonary disease (HCC 108)
CVD= cerebrovascular disease (HCCs 95-103)
VD= vascular disease (HCCs 104-105)
CAD= coronary artery disease (HCCs 81-84)
RF= renal failure (HCC 131)
1 Coefficients of HCCs 161 and 177 are constrained to be equal.
"|" means Coefficients of HCCs are constrained to be equal.
Table 6-7  
Predictive Power of Base HCC Model Adding DME and Procedure Groups

<table>
<thead>
<tr>
<th>HCC Model</th>
<th>R-squared</th>
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<tr>
<td>diagnoses only (Base)</td>
<td>11.15%</td>
</tr>
<tr>
<td>diagnoses + all HCFA DME policy groups</td>
<td>12.46%</td>
</tr>
<tr>
<td>diagnoses + HCC DME groups</td>
<td>12.23%</td>
</tr>
<tr>
<td>diagnoses + HCC DME groups + HCC procedure groups</td>
<td>12.28%</td>
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NOTES:  
From Table 6-6.

SOURCE:  Health Economics Research, Inc.
Table 6-8

Incremental Payments Associated with DME Utilization

<table>
<thead>
<tr>
<th>Base Year DME HCC</th>
<th>Incremental Payments</th>
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<tbody>
<tr>
<td>185 Oxygen</td>
<td>$6,907</td>
</tr>
<tr>
<td>186 CPAP/IPPB/Nebulizers</td>
<td>$2,285</td>
</tr>
<tr>
<td>187 Patient Lifts, POVs, Beds</td>
<td>$7,688</td>
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<tr>
<td>188 Wheelchairs, Commodes</td>
<td>$4,382</td>
</tr>
<tr>
<td>189 Walkers</td>
<td>$1,995</td>
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Comparisons:

<table>
<thead>
<tr>
<th>Comparisons</th>
<th>Incremental Payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>7  Metastatic Cancer and Acute Leukemia</td>
<td>$7,730</td>
</tr>
<tr>
<td>67  Quadriplegia</td>
<td>$4,947</td>
</tr>
<tr>
<td>72  Multiple Sclerosis</td>
<td>$1,499</td>
</tr>
<tr>
<td>80  Congestive Heart Failure</td>
<td>$1,608</td>
</tr>
<tr>
<td>108 COPD</td>
<td>$1,198</td>
</tr>
<tr>
<td>158 Hip Fracture/Dislocation</td>
<td>$184</td>
</tr>
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</table>

NOTES:
From Table 6-6.

SOURCE: Health Economics Research, Inc.
Table 6-9

Predictive Ratios for Base Model, and Models Adding DME and Procedures

<table>
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<tr>
<th>Validation Group</th>
<th>Model</th>
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<th></th>
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<tr>
<td></td>
<td>Base Base + DME</td>
<td>Base + DME, Procs</td>
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<tr>
<td>ALL ENROLLEES</td>
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<tr>
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<tr>
<td>DISABLED</td>
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<tr>
<td>FEMALE, &lt;=34</td>
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<tr>
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<tr>
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<tr>
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<tr>
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<tr>
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<tr>
<td>FEMALE, 89-94</td>
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<tr>
<td>FEMALE, 95 OR OLDER</td>
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<tr>
<td>MALE, &lt;=34</td>
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<tr>
<td>MALE, 35-44</td>
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<td>MALE, 89-94</td>
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<tr>
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<td>0.96</td>
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<tr>
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<td>HEART FAILURE / CARDIOMYOPATHY</td>
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<tr>
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<td>Base HCC</td>
<td>Base + DME</td>
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<tr>
<td>------------------</td>
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<td><strong>Multiple Diagnoses</strong>&lt;sup&gt;3&lt;/sup&gt;</td>
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<tr>
<td>DIABETES, CEREBROVASCULAR DISEASE</td>
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<tr>
<td>HEART FAILURE, COPD</td>
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<td>0.98</td>
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<tr>
<td>COPD, CORONARY ARTERY DISEASE</td>
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<td>0.99</td>
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<td>HEART FAILURE, RENAL FAILURE</td>
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<td>DIABETES, HEART FAILURE, RENAL FAILURE</td>
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</tr>
<tr>
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<td>DIABETES, CEREBROVASCULAR DISEASE, VASCULAR DISEASE</td>
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<tr>
<td><strong>Expenditures</strong></td>
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<td>FIRST (LOWEST) QUINTILE, 1996 EXPEND</td>
<td>1.23</td>
<td>1.19</td>
<td>1.19</td>
</tr>
<tr>
<td>SECOND QUINTILE, 1996 EXPEND</td>
<td>1.23</td>
<td>1.19</td>
<td>1.18</td>
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<td>MIDDLE QUINTILE, 1996 EXPEND</td>
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<td>FOURTH QUINTILE, 1996 EXPEND</td>
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<tr>
<td>FIFTH (HIGHEST) QUINTILE, 1996 EXPEND</td>
<td>0.86</td>
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<td>Top 5 percent 1996 EXPENDITURES</td>
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<td>0.81</td>
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<tr>
<td>Top 1 percent 1996 EXPENDITURES</td>
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<tr>
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<td>13.73</td>
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<tr>
<td>MIDDLE QUINTILE, 1997 EXPEND</td>
<td>5.71</td>
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<td>FOURTH QUINTILE, 1997 EXPEND</td>
<td>1.97</td>
<td>1.98</td>
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<tr>
<td>FIFTH (HIGHEST) QUINTILE, 1997 EXPEND</td>
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<td>0.39</td>
<td>0.39</td>
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<tr>
<td>No home health spending 1996</td>
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</tr>
<tr>
<td>Home health spending &gt; 0 1996</td>
<td>0.75</td>
<td>0.82</td>
<td>0.82</td>
</tr>
<tr>
<td>HHA spending&gt;0:FIRST (LOWEST) QUINTILE, 1996</td>
<td>0.99</td>
<td>1.02</td>
<td>1.02</td>
</tr>
<tr>
<td>HHA spending&gt;0:SECOND QUINTILE, 1996</td>
<td>0.98</td>
<td>1.04</td>
<td>1.04</td>
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<tr>
<td>HHA spending&gt;0:MIDDLE QUINTILE, 1996</td>
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<td>0.96</td>
<td>0.96</td>
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<td>HHA spending&gt;0:FOURTH QUINTILE, 1996</td>
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<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>HHA spending&gt;0:FIFTH (HIGHEST) QUINTILE, 1996</td>
<td>0.46</td>
<td>0.55</td>
<td>0.55</td>
</tr>
<tr>
<td>HHA spending&gt;0: top 10% of HHA spending 1996</td>
<td>0.39</td>
<td>0.47</td>
<td>0.47</td>
</tr>
<tr>
<td>HHA spending&gt;0: top 5% of HHA spending 1996</td>
<td>0.33</td>
<td>0.40</td>
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</tr>
<tr>
<td>No home health spending 1997</td>
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<tr>
<td>Home health spending &gt; 0 1997</td>
<td>0.41</td>
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<td>HHA spending&gt;0:FIRST (LOWEST) QUINTILE, 1997</td>
<td>0.53</td>
<td>0.55</td>
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<td>HHA spending&gt;0:SECOND QUINTILE, 1997</td>
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<td>0.49</td>
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<td>HHA spending&gt;0:FIFTH (HIGHEST) QUINTILE, 1997</td>
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<td>0.37</td>
<td>0.37</td>
</tr>
<tr>
<td>HHA spending&gt;0: top 10% of HHA spending 1997</td>
<td>0.29</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
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<td>0.26</td>
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</tr>
<tr>
<td>No DME spending 1996</td>
<td>1.09</td>
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</tr>
<tr>
<td>DME spending &gt; 0 1996</td>
<td>0.82</td>
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<td>DME spending&gt;0:FIRST (LOWEST) QUINTILE, 1996</td>
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<td>1.00</td>
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<td>1.00</td>
<td>1.00</td>
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<tr>
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<td>0.97</td>
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<td>0.59</td>
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<td>0.87</td>
</tr>
<tr>
<td>DME spending&gt;0: top 5% of DME spending 1996</td>
<td>0.57</td>
<td>0.81</td>
<td>0.81</td>
</tr>
</tbody>
</table>
Table 6-9 (Continued)

Predictive Ratios for Base Model, and Models Adding DME and Procedures

<table>
<thead>
<tr>
<th>Validation Group</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
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<tr>
<td>No DME spending 1997</td>
<td>1.41</td>
<td>1.35</td>
<td>1.35</td>
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<tr>
<td>DME spending &gt; 0 1997</td>
<td>0.57</td>
<td>0.64</td>
<td>0.64</td>
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<td>DME spending &gt; 0; FIRST (LOWEST) QUINTILE, 1997</td>
<td>0.76</td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td>DME spending &gt; 0; SECOND QUINTILE, 1997</td>
<td>0.58</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
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<td>0.65</td>
<td>0.69</td>
<td>0.69</td>
</tr>
<tr>
<td>DME spending &gt; 0; FOURTH QUINTILE, 1997</td>
<td>0.54</td>
<td>0.59</td>
<td>0.59</td>
</tr>
<tr>
<td>DME spending &gt; 0; FIFTH (HIGHEST) QUINTILE, 1997</td>
<td>0.47</td>
<td>0.61</td>
<td>0.61</td>
</tr>
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<td>DME spending &gt; 0; top 10% of DME spending 1997</td>
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<td>DME spending &gt; 0; top 5% of DME spending 1997</td>
<td>0.44</td>
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</tbody>
</table>

**DME**
- oxygen supplies/equipment (DME)
- wheelchairs (DME)
- walkers (DME)

**HOSPITAL ADMISSIONS**
- 0 1996 HOSP ADMISSIONS
- 1 1996 HOSP ADMISSIONS
- 2 1996 HOSP ADMISSIONS
- 3+ 1996 HOSP ADMISSIONS

<table>
<thead>
<tr>
<th>Validation Group</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
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<tr>
<td>0 1997 HOSP ADMISSIONS</td>
<td>1.03</td>
<td>1.02</td>
<td>1.02</td>
</tr>
<tr>
<td>1 1997 HOSP ADMISSIONS</td>
<td>1.02</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>2 1997 HOSP ADMISSIONS</td>
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<tr>
<td>3+ 1997 HOSP ADMISSIONS</td>
<td>0.82</td>
<td>0.84</td>
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</table>

**OUTPUT:** D9pr07ba.out and D9pr07aa.out

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.

1 Model 3 of Table 6-6
2 Model 4 of Table 6-6
3 Validation groupd diagnoses assigned using Source=1-6
7

7.1 Overview

In the preceding six chapters we have described prospective DCG/HCC models, which estimate expected year-2 costs from year-1 information. In Chapter 7, we use the same population and modeling framework to develop concurrent models, that is, models which estimate expected costs in the same year that the diagnostic information is generated. Specifically, we estimate our models using year-2 diagnoses to predict year-2 spending. Our strategy for concurrent modeling is somewhat different than previously.

First, we see concurrent models as useful primarily for provider profiling and monitoring rather than plan payment. Concurrent models may create inappropriate incentives for treatment and diagnosis, and are thus less attractive for establishing payments. If concurrent models will not be used for payment, there is no need to exclude condition categories because of concerns about incentives. Second, acute and common but minor conditions (e.g., infectious diseases, ear, nose, and throat disorders, and injuries) generate significant expenditures in the year in which they occur. But, due to greater variation in coding minor conditions as opposed to more serious chronic conditions, and their greater sensitivity to deductibles, a concurrent model may use diagnoses that are somewhat less consistently coded. Concurrent modeling is more useful, rather, in making comparison

---

1 The description of the concurrent DCG/HCC model draws upon Ash et al 1998 extensively.
within a population or among populations with similar features. Third, concurrent models predict much better than do prospective models, and it is easy to see why. For example, when we see no diagnoses listed for a woman this year, it is nearly certain that she has incurred minimal or zero costs; however, there is still a non-negligible chance that she will have a costly medical problem next year. We regard it as a sign of the success of our concurrent models that once diagnoses are taken into account, there is little additional explanatory power added by considering age and sex groups. In our preferred specifications, we omit age and sex categories altogether from the concurrent models. To avoid negative predicted payments, we also constrain intercept terms.

The first two stages in creating concurrent models were exactly the same as with prospective DCG models. ICD-9-CM diagnoses from 1997 were first aggregated into 804 DxGroups using the same classification system as for the prospective model. Although the primary focus in designing the DxGroups was on prospective modeling, in some cases separate DxGroups were created to differentiate clusters of diagnoses that predict concurrent, rather than future, costs. As can be seen in Table A-3 of DxGroup means in the appendix, the DxGroups identify many meaningful categories of concurrent resource use, for example, 106.06 varicose veins, 106.10 hemorrhage nos, 14.01 benign neoplasm of skin, and 91.01 essential hypertension.

Next we aggregate the DxGroups into 184 of the 189 Condition Categories (CCs). We chose a priori not to include the five HCCs defined solely by DME claims. In our initial development of DCG models (Ellis et al., 1996), we used one set of CCs and
hierarchies for our concurrent models and a generally similar set of CCs for our prospective models. Here we follow Ash et al., 1998 and Pope et al, 1998 in using exactly the same classification system and hierarchies for both concurrent and prospective models. Differences between concurrent and prospective frameworks derive from differences in coefficients, not from different groupings of diagnoses into condition categories.

One small difference in the concurrent modeling is that we use end-of-year age instead of beginning-of-year age (as was used for prospective modeling). This accommodates newborns, who would otherwise be assigned negative concurrent ages. It also permits both prospective and concurrent models to be estimated from the same set of explanatory variables.

We first used only age and sex to predict costs in 1997. Then we estimated four types of models, similar to those examined prospectively, only this time using diagnostic and demographic information from 1997 to predict costs in the same year. For our concurrent model, following the sample selection criteria described in Chapter 2, we included anyone eligible for coverage in at least one month in 1997. This resulted in an estimation sample of 1,581,370. The sample includes all people included in the prospective modeling subset of our Prospective sample, and additionally those people who became eligible for Medicare during 1996 or 1997. See Table 3-4 in Chapter 3 for descriptive statistics on the overall concurrent sample, and by concurrent HCC.
7.2 Process of Selection

The first two columns of numbers in Table 7-1 show the coefficients and t-ratios from the first model, an Age/Sex Only model. At the top of the two columns, the model’s $R^2$ value is shown as 1.08 percent. As seen in the prospective modelling, coefficients on the age cohorts are monotonic except that the 65-69 year old age groups for both sexes cost less than the age 55-64 group, and the two oldest groups (ages 95 and over) cost less than the 90 to 94-year olds. Starting on the second page of the table, the first column shows the number of person years falling in each HCC in the concurrent sample. Although this column repeats information that is also presented in Table 3-4, it is useful here for interpreting coefficients. In particular, it reminds us that some sample cell sizes are small.

The second model adds binary dummy variables for each of the 184 HCCs to the 24 age-sex dummies without imposing any exclusions. This model has much higher explanatory power than any prospective model: its $R^2$ is 52.44 percent versus 11.15 percent for the base prospective model. There are 22 negative coefficients, notably in the Mental Retardation/Developmental Disability HCCs, and various low cost HCCs. In several cases, monotonicity of the HCCs in a hierarchy is not satisfied, such that lower ranked HCCs have larger cost weights than higher ranked HCCs. Most coefficients are substantially larger than those of the prospective model. The age-sex coefficients are all negative and show a pattern that is the opposite of the simple Age/Sex Only model. Medicaid status (eligibility in 1997) is small and slightly positive ($73, t = 3.01$), while
the coefficient on originally disabled is negative. Taken together, the coefficients indicate that the observed demographic cost pattern is largely explained in a concurrent model by diagnostic information, with little variation explained by the demographic variables once the diagnoses are accounted for.

The next step in model development was to impose constraints to eliminate negative coefficients. We find it undesirable to have negative coefficients for any age/sex cells, which wrongly assign negative expected costs to the many individuals in these cells who have no 1997 diagnoses (HCCs). Therefore we constrain all the age-sex coefficients to be zero, and instead capture the expected costs for people with no diagnoses in a single constant term (the intercept). We also dropped the Medicaid status and originally disabled variables (that is, we set their coefficients to zero) because they add little information in the concurrent setting. Also, it is undesirable for any risk adjustment model (whether intended for payment, monitoring or profiling) to reduce its predicted cost when either any new medical condition is added to a person’s profile, or when a more serious condition is coded rather than one that indicates lesser severity. Hence, for reasons similar to those stated for the prospective model, we constrain coefficients to remove negatives and non-monotonic coefficients in the same hierarchy. For example, although the unconstrained coefficient of HCC 67 Quadriplegia, Other Extensive Paralysis is somewhat smaller than that for HCC 68 Paraplegia, our constrained model contains only a single coefficient for all people with diagnoses in either category.
These changes have little effect on the remaining coefficients or the $R^2$, which is now 52.31 percent, down from 52.45 percent. One new problem, however, arises; instead of numerous negative age/sex constants, we now have a single, highly significant, negative intercept. We address this problem by omitting the intercept, but including a new variable (NOHCC) to ensure that all predictions are positive.

For the fourth model shown in Table 7-1, we replace the intercept with the dummy NOHCC, which equals one if the beneficiary does not have any HCC used in calculating predictions. Note that NOHCC indicates more than people with no valid diagnoses recorded – some of these people had HCCs for lower cost conditions which were excluded from the model because they were negative. NOHCC is a marker for people with “no HCC that leads to increased predicted expenditures.”

Preliminary versions of Model 4, (not shown in Table 7-1) using the NOHCC variable, had many HCCs with coefficients smaller than the one for NOHCC. This violates monotonicity, since a person with no HCCs then receives a higher prediction than someone with a single, low-cost HCC. Therefore, in our final preferred specification we constrain any HCCs with coefficients that are less than the NOHCC coefficient to be zero. This requires recalculating the NOHCC variable. The final preferred specification has a NOHCC coefficient of $353, and only 117 parameters. This implies that only 116 HCC parameters are estimated for the 184 HCCs. An additional 6 HCCs are assigned weight in the prediction while constrained to be equal to other HCC coefficients. A total
of 62 HCCs, mostly lower cost ones, have a zero coefficient, and their costs are picked up in the single NOHCC (“not in any prediction-increasing HCC”) variable.

The final concurrent model, shown as Model 4 of Table 7-1, has generally plausible coefficients on each of the non-zero HCCs. The $R^2$ is an impressive 52.15 percent, down only slightly from the 52.45 percent when no constraints or exclusions are imposed. The 3 highest cost groups are “77 Respirator Dependence/Tracheostomy Status (incremental cost = $42,450)”, “150 Extensive Third Degree Burns ($33,801)”, and “78 Respiratory Arrest ($17,606).” These high cost groups have good face validity.

Using results from Model 4, Figure 7-1 presents a comparison of predicted and actual levels of spending for people in each of 22 predicted-cost categories, known as DCGs. The lowest-cost group has DCG-predicted costs of $300-399, the second lowest encompasses predicted costs of $400-499, ranging up to a top group with model-predicted costs of $70,000 or more. Points are located along the X-axis corresponding to the DCG category dollar labels. The Y-axis values are (weighted) average actual expenditures for the groups of people. Both actual and predicted costs are plotted. Clearly, the concurrent model successfully discriminates costs, identifying substantial subgroups of Medicare enrollees with very high and very low costs.

7.3 Alternative Concurrent Models

\footnote{See Table 3-4 of Chapter 3 for descriptive statistics on NOHCC for the base concurrent model (Model 4 in Table 7-1).}
In addition to our base concurrent model shown as Model 4 of Table 7-1, we explored two alternative concurrent models. The two alternative models are discussed in turn in Sections 7.3.1 and 7.3.2, and shown in Table 7-2 as Models 5 and 6 along with our base concurrent Model 4 repeated from Table 7-1. The first additional concurrent model is a profiling model that could be used as an alternative to the base concurrent model. The second additional concurrent model is a payment version of the concurrent model. The additional models may be useful for different purposes than the base concurrent model.

### 7.3.1 Alternative Profiling Model

The first alternative begins by \textit{a priori} constraining certain HCC coefficients equal to zero, then using the same model selection process as described in Section 7.2. This process differs from the base model, in which no HCCs (other than the DME-based HCCs) were excluded from the model \textit{a priori}. The HCCs constrained \textit{a priori} to be zero included:

1) Selected HCCs that represent the process or outcome of medical care as opposed to clinical diagnoses (HCCs 175, 179-189).

These HCCs are based on ICD-9-CM "V" codes, or on DME HCPCS procedure codes. Examples of these HCCs are HCC 179 "Post-Surgical States/Aftercare/Elective", HCC 181 "Chemotherapy", HCC 182 "Rehabilitation", and HCC 183
"Screening/Observation/Special Exams". All DME groups (HCCs 185-189, e.g., "wheelchair") are also excluded as part of this group (the DME HCCs are not included in our base concurrent Model 4 either).

Note that we do not exclude all V-code-based HCCs from this alternative concurrent model. For example, we continue to include HCC 174 "Major Organ Transplant Status" and HCC 177 "Amputation Status, Lower Limb/Amputation Complications". Our clinical panel considered these categories to be better defined and less subject to practice style and coding variations than the excluded HCCs.

2) Diagnoses representing complications of medical care (HCCs 164-165).

3) HCCs that represent symptoms (HCCs 166-167).

4) Neonatal diagnoses (HCCs 168-172).

5) Diagnostic categories that may be vague, gameable, imperfectly coded, or not necessarily indicative of serious illness (HCCs 23, 47, 133-136).

The diagnoses in category 5 are strongly correlated with costs, but the diagnoses themselves are often acting as proxies for other, underlying serious conditions. These diagnoses themselves are not necessarily serious or even directly indicative of an underlying serious condition. They are more likely to be erratically coded. Examples include HCC 23 "Disorders of Fluid/Electrolyte/Acid-Base Balance", HCC 47 "Iron Deficiency and Other/Unspecified Anemias and Blood Disease", and HCC 134 "Incontinence".
By excluding these five categories of diagnoses, the costs they capture are reassigned to other diagnostic categories, which better measure underlying, serious disease (e.g., cancer, heart disease, stroke, etc.). A concurrent profiling model excluding these HCCs may be preferred by some because it emphasizes underlying, serious clinical diagnoses, and is less confounded by the process and complications of care, symptoms, and discretionary diagnoses. On the other hand, because we conceptualize this model as a concurrent profiling model, we retain in this variant more HCCs than are allowed in the prospective HCC payment model (see Section 4.6). For example, we do not exclude diagnoses that are expected to generate significant current year, but not necessarily subsequent year, expenditures, such as HCC 35 "Appendicitis" and HCC 30 "Gallbladder and Biliary Tract Disorders".

We estimated a concurrent model with the coefficients of the HCCs identified above set to zero. Then we went through the same process of model selection as described above in Section 7.2 for the base concurrent model. That is, we set negative coefficients equal to zero, constrained coefficients where hierarchies were violated, excluded all age/sex and other demographic variables\(^3\), dropped the regression intercept (constant) term\(^4\), introduced a "No HCC" variable, and excluded all HCCs with coefficients less than the NOHCC coefficient, incorporating them into the NOHCC variable.

---

\(^3\) These variables were excluded because their coefficients were negative or close to zero.

\(^4\) The intercept was excluded because it was negative.
The final alternative concurrent profiling model is shown as Model 5 in Table 7-2. Table 7-2 has the same format as Table 7-1. Model 4 from Table 7-1 (our base concurrent model) is repeated in Table 7-2 for comparison with these two alternative concurrent models (Models 5 and 6). The alternative profiling model (Model 5) contains
10 fewer parameters than the base model (Model 4). Mostly, these are accounted for by the explicit exclusions of HCCs from the alternative model. On the other hand, the alternative model retains some HCCs that are excluded from the base model: for example, HCC 39 "Disorders of the Vertebrae and Spinal Discs", HCCs 56, 57, and 58, "Reactive/Unspecified Psychosis", "Personality Disorders", and "Depression", respectively, and HCC 118 "Retinal Detachment". Reflecting the greater exclusions from the alternative model, its NOHCC coefficient is $412, slightly greater than in the base model ($353). As expected, the coefficients of serious illnesses such as cancer, heart disease, and stroke are higher in the alternative model than in the base model. These diagnoses carry more of the predictive "load" in the alternative model, because HCCs representing symptoms, medical care or its complications, and less fundamental ancillary diagnoses are excluded. Excluding these diagnoses does come at a cost in predictive power: the R-square of the alternative model declines to 49.44% from 52.15% for the base model.

7.3.2 Payment Model

The second alternative concurrent model we estimated excluded a priori the same HCC categories as were excluded from the base prospective payment model (see Section 4.6 for a discussion of the base prospective payment model). The criteria for including diagnoses in a payment model are more stringent than for including them in a profiling model (see Section 3.1 for a discussion of criteria for excluding diagnoses from a...
payment model). Hence, the second alternative concurrent model includes fewer HCCs than the other two concurrent models. Although we generally prefer the use of prospective risk adjustment models for payment purposes, there may be some circumstances in which use of a concurrent model is necessary (e.g., only one year of data are available) or desirable (e.g., a "casemix" adjuster is desired). We estimated a "payment" version of the concurrent model for use in these cases.

After making the a priori exclusions of HCCs, we used the same model selection process as was used for the other two concurrent models. That is, we set negative coefficients equal to zero, constrained coefficients where hierarchies were violated, excluded all age/sex and other demographic variables, dropped the regression intercept (constant) term, introduced a "No HCC" variable, and excluded all HCCs with coefficients less than the NOHCC coefficient, incorporating them into the NOHCC variable. The final payment concurrent model is shown as Model 6 of Table 7-2.

The number of parameters in the payment concurrent model is 89, 28 fewer than in the base concurrent model (Model 4), and 10 fewer than in the alternative concurrent profiling model (Model 5). This reflects the more stringent criteria for including diagnoses in a payment model. Note that the HCCs included in the concurrent payment model are not identical to those included in the prospective payment model. For example, although not excluded a priori, HCC 118 "Retinal Detachment" was excluded.

---

5 These variables were excluded because their coefficients were negative or close to zero.
6 The intercept was excluded because it was negative.
from the final prospective model because it had a coefficient insignificantly different from zero (see Table 4-2). But in the concurrent estimation, HCC 118 has a statistically significant positive coefficient greater than NOHCC's coefficient, so it is included in the concurrent payment model (Model 6 of Table 7-2). Conversely, HCC 19 "Diabetes with No or Unspecified Complications" is included in the base prospective model (Table 4-2), but not in the concurrent payment model because its coefficient is less than NOHCC's coefficient in the concurrent estimation and thus it is incorporated into the NOHCC variable. Despite these exceptions and a few others, the HCCs included in the prospective and concurrent payment models are quite similar overall (compare Model 5 of Table 4-2 to Model 6 of Table 7-2).

Because of the greater number of exclusions from the payment model, NOHCC's coefficient rises to $613, considerably larger than in either of the two concurrent profiling models (Models 4 and 5 in Table 7-2). NOHCC's coefficient is the predicted payment assigned to all beneficiaries not assigned to an HCC included in the final model. The overall predictive power of the payment model, an R-square of 49.05%, is only slightly lower than the alternative profiling model (Model 5), but several percentage points less than the base concurrent model (Model 4). Again, this reflects the a priori exclusion of certain HCCs that, while they contribute to predictive power, may create undesirable incentives in a payment model.

---

7 An insignificant coefficient in the prospective model indicates that retinal detachment is not associated with elevated future medical expenditures, holding constant other diagnoses and demographic factors.
# Concurrent Medicare Models Using 1997 Data

<table>
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<th>Model Name</th>
<th>Number of Obs</th>
<th>Dependent Variable Mean</th>
<th>Model Parameters</th>
<th>Adj. R-Square</th>
<th>Computer Output</th>
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Concurrent Medicare Models Using 1997 Data
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Health Economics Research, Inc.  
DCG/HCC Models for Medicare Risk Adjustment: 7-19
### Table 7-1 (continued)
Concurrent Medicare Models Using 1997 Data

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<td>185 Oxygen</td>
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Table 7-1 (continued)

Concurrent Medicare Models Using 1997 Data

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<td>188 Wheelchairs, Commodes</td>
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<td>189 Walkers</td>
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</table>

Female 65-69 is the omitted category in the age/sex model. Predicted expenditures for this age/sex group are given by the intercept term, and predicted expenditures for all other age/sex groups are obtained by adding the intercept to their coefficient.

Figure 7-1

Comparison of Actual and DCG/HCC Predicted Concurrent Spending

DCG prediction intervals

$0$ to $10,000$
$10,000$ to $14,999$
$15,000$ to $19,999$
$20,000$ to $24,999$
$25,000$ to $29,999$
$30,000$ to $34,999$
$35,000$ to $39,999$
$40,000$ to $49,999$
$50,000$ to $59,999$
$60,000$ to $69,999$
$70,000$ +

Annual Payments

$0$
$20,000$
$40,000$
$60,000$
$80,000$
$100,000$
$120,000$

DCG Predicted
Actual
**Table 7-2**

Alternative Concurrent Medicare Models Using 1997 Data

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<td>Male, age 45 to 54</td>
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<tr>
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<tr>
<td>Female, age 60 to 64</td>
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<td>Female, age 75 to 79</td>
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<td>Female, age 80 to 84</td>
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<td>Female, age 85 to 89</td>
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<td>Female, age 90 to 94</td>
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Base Model\(^1\) | Alternative Profiling | Payment Model

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**Health Economics Research, Inc.**

DCG/HCC Models for Medicare Risk Adjustment: 7-23
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<th>Parameters</th>
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### Table 7-2 (continued)

**Alternative Concurrent Medicare Models Using 1997 Data**

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Table 7-2 (continued)

Alternative Concurrent Medicare Models Using 1997 Data

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Table 7-2 (continued)

Alternative Concurrent Medicare Models Using 1997 Data

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### Table 7-2 (continued)

**Alternative Concurrent Medicare Models Using 1997 Data**

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1 Repeated from Model 4 of Table 7-1.

**SOURCE:** Health Economics Research, Inc. analysis of 1997 Medicare claims data.
References


## Table A-1
Hierarchical Condition Categories

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<td>6.09 Viral hepatitis A and unspecified, without hepatic coma</td>
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<td>6.10 Other infections</td>
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<td>6.11 Lyme disease</td>
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<td>6.12 Veneral diseases, except neuro-and cardiovascular syphilis</td>
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<td>6.13 Dermatophytosis (fungal skin infections, e.g., athlete's foot)</td>
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<td>6.14 Oral candidiasis (thrush)</td>
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<td>6.15 Histoplasmosis/coccidioidomycosis/blastomycosis</td>
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<td>6.16 Infection late effects, excluding central nervous system</td>
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<td>6.17 Bactremia</td>
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<td>7. Metastatic Cancer and Acute Leukemia</td>
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<td>7.01 Secondary cancer of lymph node</td>
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<td>7.02 Secondary cancer of respiratory and digestive systems</td>
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<td>7.03 Secondary cancer of other site</td>
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<td>7.04 Disseminated cancer</td>
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<tr>
<td>7.05 Acute lymphoid and other acute leukemias, except myeloid</td>
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<td>7.06 Acute myeloid leukemia</td>
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<td>8. Lung, Upper Digestive Tract, and Other Severe Cancers</td>
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<td>Neoplasm 2</td>
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<tr>
<td>8.01 Cancer of esophagus</td>
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<tr>
<td>8.02 Cancer of stomach</td>
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<td>8.03 Cancer of small bowel/peritoneum/gallbladder/bile ducts</td>
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<td>8.04 Cancer of liver</td>
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<td>8.05 Cancer of pancreas</td>
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<tr>
<td>8.06 Cancer of trachea, bronchus, lung, and pleura</td>
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<td>8.07 Multiple myeloma</td>
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<tr>
<td>8.08 Chronic myeloid and other specific non-acute leukemias, except lymphoid</td>
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<td>9. Lymphatic, Head and Neck, Brain, and Other Major Cancers</td>
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<td>Neoplasm 3</td>
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<tr>
<td>9.01 Cancer of mouth/tongue</td>
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<td>9.02 Cancer of pharynx</td>
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<tr>
<td>9.03 Other respiratory/intrathoracic cancer</td>
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<td>9.04 Cancer of larynx</td>
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<td>9.05 Cancer of bone and articular cartilage</td>
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<tr>
<td>9.06 Cancer of connective and other soft tissue</td>
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## Table A-1 (continued)

### Hierarchical Condition Categories

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<th>If in this HCC then Model Exclusions</th>
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<tbody>
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<td>Ignore HCC:</td>
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9.07 Kaposi’s sarcoma
9.08 cancer of ovaries/placenta/uterine adnexia
9.09 cancer of the brain/nervous system/pituitary, pineal glands
9.10 adrenal gland cancer
9.11 non-Hodgkin’s lymphomas
9.12 Hodgkin’s disease
9.13 chronic lymphoid and unspecified cell leukemias, not specified as acute

#### 10 Breast, Prostate, Colorectal and Other Cancers and Tumors

| 10.01 colon cancer |
| 10.02 rectal cancer |
| 10.03 other, unspecified cancer of digestive organs/peritoneum |
| 10.04 melanoma |
| 10.05 breast cancer, age 45+ |
| 10.06 cancer of uterus |
| 10.07 cancer of cervix/female genital organs |
| 10.08 prostate cancer |
| 10.09 cancer of testis/male genital organs |
| 10.10 cancer of bladder, ureter, urethra and other urinary tract |
| 10.11 cancer of kidney and renal pelvis |
| 10.12 cancer of the eye |
| 10.13 thyroid/endocrine cancer, except adrenal, pituitary, pineal |
| 10.14 other/fill-defined site cancer |
| 10.15 benign neoplasm of brain/nervous system/pituitary, pineal glands |
| 10.16 uncertain/unspecified neoplasm of brain/nervous system/pituitary, pineal glands |
| 10.17 neurofibromatosis |
| 10.18 tuberous sclerosis and other hamartoses (Peutz-Jeghers/Sturge-Weber, etc) |
| 10.19 breast cancer, age < 45 |

#### 11 Other Respiratory and Heart Neoplasms

| 11.01 benign neoplasm of respiratory system |
| 11.02 benign neoplasm of heart |
| 11.03 carcinoma in situ of respiratory system |
| 11.04 uncertain/unspecified neoplasm of respiratory system |

#### 12 Other Digestive and Urinary Neoplasms

| 12.01 benign neoplasm of digestive system |
| 12.02 benign neoplasm of urinary tract |
| 12.03 carcinoma in situ of digestive organs |
| 12.04 carcinoma in situ of urinary organs |
| 12.05 uncertain/unspecified neoplasm of digestive organs |
| 12.06 uncertain/unspecified neoplasm of urinary organs |

#### 13 Other Neoplasms

| 13.01 skin cancer, except melanoma, including lip |
| 13.02 benign neoplasms, exc respiratory, digestive, urinary, skin, breast, eye, cns |
| 13.03 carcinoma in situ, except respiratory, digestive, urinary, skin |
| 13.04 uncertain neoplasm, exc respiratory, digestive, urinary, skin |
| 13.05 unspecified neoplasm, exc respiratory, digestive, bladder, brain |

#### 14 Benign Neoplasms of Skin, Breast, Eye

| 14.01 benign neoplasm of skin |
| 14.02 benign neoplasm of breast/other breast disorders |
| 14.03 benign neoplasm of eye |
| 14.04 uncertain neoplasm, skin |

#### 15 Diabetes with Renal Manifestation

| 15.01 type II diabetes with renal manifestation |
| 15.02 type I diabetes with renal manifestation |

#### 16 Diabetes with Neurologic or Peripheral Circulatory Manifestation

| 16.01 type II diabetes with neurologic manifestations |
| 16.02 type I diabetes with neurologic manifestations |
| 16.03 type II diabetes with peripheral circulatory disorders |
| 16.04 type I diabetes with peripheral circulatory disorders |
| D 71.04 diabetic neuropathy |

#### 17 Diabetes with Acute Complications

| 17.01 type II diabetes with ketocidosis or coma |

| Health Economics Research, Inc. |
| DCG/HCC Models for Medicare Risk Adjustment: A-2 |
Table A-1 (continued)

**Hierarchical Condition Categories**

<table>
<thead>
<tr>
<th>If in this HCC then Ignore HCC:</th>
<th>Exclusions Name</th>
<th>Payment Model Name</th>
<th>Short HCC Name</th>
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<td>17.02 type I diabetes with ketoacidosis or coma</td>
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<tr>
<td>17.03 type II diabetes with other specified manifestations, incl hypoglycemic shock</td>
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<tr>
<td>17.04 type I diabetes with other specified manifestations, incl hypoglycemic shock</td>
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<tr>
<td>18 Diabetes with Ophthalmologic Manifestation</td>
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<tr>
<td>18.01 type II diabetes with ophthalmologic manifestations</td>
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<tr>
<td>18.02 type I diabetes with ophthalmologic manifestations</td>
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<td>D 119.01 proliferative diabetic retinopathy</td>
<td>Diabetes 4</td>
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<tr>
<td>D 120.01 diabetic retinopathy</td>
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<tr>
<td>19 Diabetes with No or Unspecified Complications</td>
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<td>19.01 type II diabetes without complications</td>
<td>Diabetes 5</td>
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<td>19.02 type I diabetes without complications</td>
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<tr>
<td>19.03 type II diabetes with unspecified complication</td>
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<tr>
<td>19.04 type I diabetes with unspecified complication</td>
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<td>D 146.07 diabetes mellitus complicating pregnancy</td>
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<td>20 Type I Diabetes Mellitus</td>
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<tr>
<td>D 15.02 type I diabetes with renal manifestation</td>
<td>Diabetes 6</td>
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<tr>
<td>D 16.02 type I diabetes with neurological manifestations</td>
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<tr>
<td>D 16.04 type I diabetes with peripheral circulatory disorders</td>
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<tr>
<td>17.02 type I diabetes with ketoacidosis or coma</td>
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<td>D 17.04 type I diabetes with other specified manifestations</td>
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<tr>
<td>D 18.02 type I diabetes with ophthalmologic manifestations</td>
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<tr>
<td>D 19.02 type I diabetes without complications</td>
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<tr>
<td>D 19.04 type I diabetes with unspecified complication</td>
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<td>21 Protein-Calorie Malnutrition</td>
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<td>21.01 protein-calorie malnutrition/wasting disease (cachexia)</td>
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<td>22 Other Significant Endocrine and Metabolic Disorders</td>
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<td>22.01 adrenal gland disorders e.g., Cushing's syndrome</td>
<td>Metabolic 2</td>
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<tr>
<td>22.02 non diabetic hypoglycemic coma</td>
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<td>22.03 pituitary/parathyroid/thyroid/polyglandular disorders, except pituitary dwarfism</td>
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<td>22.04 pituitary dwarfism</td>
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<td>22.05 inborn errors of metabolism</td>
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<td>22.06 macroglobulinemia and paraproteinemias, except monoclonal</td>
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<td>22.07 hemochromatosis, other disorders of iron, copper, and phosphorus metabolism</td>
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<td>22.08 porphyria, histiocytosis, other specified metabolic disorders</td>
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<td>22.09 amyloidosis/familial Mediterranean fever</td>
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<td>22.10 alpha 1-antitrypsin deficiency/hereditary angiodema</td>
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<td>23 Disorders of Fluid/Electrolyte/Acid-Base Balance</td>
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<td>24 Other Endocrine/Metabolic/Nutritional Disorders</td>
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<td>24.01 goiter</td>
<td>Metabolic 4</td>
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<td>24.03 congenital hypothyroidism (cretinism)</td>
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<td>24.04 thyroid disorders, except goiter and thyrotoxicosis</td>
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<td>24.05 other hypoglycemia</td>
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<td>24.06 ovarian dysfunction</td>
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<td>24.07 testicular dysfunction</td>
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<td>24.08 other endocrine disorders</td>
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<td>24.09 vitamin B/other nutritional deficiencies</td>
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<td>24.10 lactose intolerance, other/unspecified disorders of carbohydrate metabolism</td>
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<td>24.11 disorders of lipid metabolism (high cholesterol), except lipidoses</td>
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<td>24.13 disorders of magnesium, calcium, and unspecified mineral metabolism</td>
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<td>24.14 disorders of bilirubin excretion and unspecified metabolism disorders</td>
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<td>25 End-Stage Liver Disease</td>
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<td>25.01 esophageal varices</td>
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<td>25.02 end stage liver disorders, including hepatic coma and liver failure</td>
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<td>26 Cirrhosis of Liver</td>
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<td>26.01 cirrhosis of liver</td>
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<td>27 Chronic Hepatitis</td>
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<td>27.01 chronic viral hepatitis</td>
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<td>27.02 chronic hepatitis, except viral</td>
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<td>28 Acute Liver Failure/Disease</td>
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<td>Liver 3</td>
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<td>28.02 viral hepatitis, acute or unspecified, with hepatic coma</td>
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<td>29 Other Hepatitis and Liver Disease</td>
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<td>30 Gallbladder and Biliary Tract Disorders</td>
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<td>30.02 specified biliary tract disease (e.g., cholangitis, obstruction, perforation)</td>
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<td>31 Intestinal Obstruction/Perforation</td>
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<td>31.01 peritonitis, excluding appendicitis and female pelvic</td>
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<td>31.02 perforated peptic ulcer or intestines</td>
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<td>33 Inflammatory Bowel Disease</td>
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<td>33.01 regional enteritis (Crohn's disease), age 18+</td>
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<td>33.02 ulcerative colitis, age 18+</td>
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<td>33.03 inflammatory bowel disease, age ≤ 18</td>
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<td>34 Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders</td>
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<td>34.01 bacterial enteritis (intestinal infections)</td>
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<td>34.02 peptic ulcer not specified as with perforation, hemorrhage, or obstruction</td>
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<td>34.03 gastrointestinal hemorrhage, except peptic ulcer and anal/rectal</td>
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<td>34.04 peptic ulcer with hemorrhage, without perforation</td>
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<td>34.05 peptic ulcer with obstruction, without perforation or hemorrhage</td>
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<td>34.06 pyloric/duodenal obstruction</td>
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<td>34.07 intestinal abcess, fistula, and other specified disorders</td>
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<td>34.08 abdominal hernia, complicated</td>
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<tr>
<td>34.09 peritoneal disorders, except peritonitis</td>
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<td>35 Appendicitis</td>
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<td>35.01 appendicitis, including with perforation and peritonitis</td>
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<td>36 Other Gastrointestinal Disorders</td>
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<td>36.04 abdominal hernia/uncomplicated</td>
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<td>36.05 other and unspecified intestinal disorders</td>
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<td>36.06 diverticula of intestine, without hemorrhage</td>
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<td>36.07 anal/rectal disorders</td>
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<td>36.08 gallstones without gallbladder inflammation</td>
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<tr>
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<td>37 Bone/Joint/Muscle Infections/Necrosis</td>
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<td>38 Rheumatoid Arthritis and Inflammatory Connective Tissue Disease</td>
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### Hierarchical Condition Categories

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<td>Disorders of the Vertebrae and Spinal Discs</td>
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<td>Osteoporosis and Other Bone/ cartilage Disorders</td>
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<td>osteomalacia/rickets, except vitamin D-resistant</td>
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<td>41.02</td>
<td>other bone/cartilage disorders (e.g., Paget's disease)</td>
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<td>Congenital/developmental Skeletal and Connective Tissue Disorders</td>
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<td>congenital hip dislocation/dysplasia</td>
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<td>osteogenesis imperfecta and other osteodystrophia</td>
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<td>Marfan and Ehlers-Danlos syndromes</td>
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<td>Other Musculoskeletal and Connective Tissue Disorders</td>
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<td>43.01</td>
<td>Reiter's syndrome</td>
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<td>43.02</td>
<td>gout/crystal arthropathy</td>
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<td>cleft lip/cleft palate</td>
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<td>43.12</td>
<td>other congenital musculoskeletal abnormalities</td>
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<td>43.14</td>
<td>dislocation (displacement/subluxation) of vertebra</td>
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<td>44</td>
<td>Severe Hematological Disorders</td>
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<td>44.01</td>
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<td>Disorders of Immunity</td>
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<td>immune disorders, age 18+</td>
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<td>agranulocytosis, chr granulomatous dis, oth spec white blood cell dis, age 18+</td>
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<td>thalassemias and other hereditary hemolytic anemias</td>
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**Table A-1 (continued)**
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<td>DD 6</td>
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<td>69,76,100,101,103,157,162</td>
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<td>67.06 traumatic complete lesion cervical (C1-C7) spinal cord</td>
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<td>71</td>
<td>76</td>
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<td>72</td>
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<td>76</td>
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### Hierarchical Condition Categories

**Table A-1 (continued)**

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<td>75.02 coma, nontraumatic</td>
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<td>75.03 persistent vegetative state</td>
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<td>Mononeuropathy, Other Neurological Conditions/Injuries</td>
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<td>76.06 other cranial nerve disorders</td>
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<td>76.09 root/plexus lesions</td>
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<td>76.12 abnormal involuntary movements nec (e.g. spasms/tremor nos)</td>
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<td>76.13 nerve injury, excluding spinal cord and brain</td>
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<td>77.04 ventilator (DME)</td>
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<td>D 131.03 hypertensive heart/renal disease, with heart/renal failure</td>
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<td>D 86.04 rheumatic heart failure</td>
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<td>Heart Infection/Inflammation, Except Rheumatic</td>
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Health Economics Research, Inc. DCG/HCC Models for Medicare Risk Adjustment: A-8
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<td><strong>93 Other Heart Rhythm and Conduction Disorders</strong></td>
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<td>Diplegia (Upper), Monoplegia, and Other Paralytic Syndromes</td>
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<td>Speech, Language, Cognitive, Perceptual Deficits</td>
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<td>Vascular Disease</td>
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<td>Cystic Fibrosis</td>
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<td>Chronic Obstructive Pulmonary Disease</td>
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<td>109.02 bronchiectasis</td>
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<td>109.03 pneumoconioses/lung disease due to specified external agents (e.g., black lung)</td>
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<td>109.04 respiratory conditions due to other and unspecified external agents</td>
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#### Hierarchical Condition Categories

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<td><strong>Asthma</strong>&lt;br&gt;110.01 asthma, except chronic obstructive</td>
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<td><strong>Aspiration and Specified Bacterial Pneumonias</strong>&lt;br&gt;111.01 pneumococcal pneumonia&lt;br&gt;111.02 aspiration pneumonia</td>
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<td><strong>Pneumococcal Pneumonia, Empyema, Lung Abscess</strong>&lt;br&gt;112.01 pneumococcal and other specific bacterial pneumonia&lt;br&gt;112.02 empyema, lung abscess&lt;br&gt;112.03 fungal and parasitic lung infections, except candida</td>
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<td><strong>Viral and Unspecified Pneumonia, Pleurisy</strong>&lt;br&gt;113.01 viral pneumonia&lt;br&gt;113.02 other and unspecified pneumonia&lt;br&gt;113.03 influenza with pneumonia&lt;br&gt;113.04 pleurisy, excluding pleural effusion&lt;br&gt;113.05 pulmonary congestion/hypostasis</td>
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<td><strong>Pleural Effusion/Pneumothorax</strong>&lt;br&gt;114.01 pleural effusion&lt;br&gt;114.02 pneumothorax (not tension)&lt;br&gt;114.03 tension pneumothorax (collapsed lung)</td>
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<td><strong>Other Lung Disorders</strong>&lt;br&gt;115.01 acute or unspecified bronchitis and bronchiolitis&lt;br&gt;115.02 influenza, except that with pneumonia&lt;br&gt;115.03 other and unspecified lung/respiratory system disease&lt;br&gt;115.04 atelectasis/pulmonary collapse&lt;br&gt;115.05 congenital lung/respiratory system anomaly&lt;br&gt;115.06 foreign body trachea/bronchus/lung</td>
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<td>116</td>
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<td><strong>Diabetic and Other Vascular Retinopathies</strong>&lt;br&gt;120.01 diabetic retinopathy&lt;br&gt;120.02 vascular retinopathies, except diabetic&lt;br&gt;120.03 retinal hemorrhage, edema</td>
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<td><strong>Retinal Disorders, Except Detachment and Vascular Retinopathies</strong>&lt;br&gt;121.01 retinal defects without detachment&lt;br&gt;121.02 other and unspecified retinal disorders&lt;br&gt;121.03 macular degeneration&lt;br&gt;121.04 retinitis pigmentosa, other hereditary retinal dystrophies</td>
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Table A-1 (continued)
Hierarchical Condition Categories

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<td>124.09 open wound of ocular adnexa, foreign body on external eye, burn eye/adnexa</td>
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<td>125.03 mastoiditis and related conditions</td>
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<td>127.10 disorders of teeth, gum, and jaw (e.g., gingivitis, periodontitis)</td>
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<td>127.12 salivary gland diseases</td>
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<td>132,136</td>
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Table A-1 (continued)  

Hierarchical Condition Categories

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### Table A-1 (continued)

#### Hierarchical Condition Categories

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### Table A-1 (continued)

#### Hierarchical Condition Categories

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<td>158.01 pathological hip fracture</td>
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<td>159.01 pathological fracture of humerus</td>
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<td>Injury 7</td>
<td>162</td>
<td>160.01 injury to heart/lung/intrathoracic organs/blood vessels of thorax</td>
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<td>162.177,178</td>
<td>161.01 traumatic amputation of leg/arm/hand/foot/toe, compl reattached body part</td>
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<td>Injury 9</td>
<td>162</td>
<td>162.01 unspecified pathological fractures</td>
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<td>162.02 pathological fracture of distal radius and ulna</td>
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<td>162.04 fracture of rib, closed</td>
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<td>162.06 fracture of hand/wrist/lower arm</td>
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<td>162.08 fractures of unspecified bones</td>
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<td>162.09 traumatic dislocations, except knee, shoulder, and vertebrae</td>
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<td>162.14 open wound/injury of lower arm</td>
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<td>162.15 injury late effects, except spinal cord, skull/face fracture, and intracranial</td>
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<td>162.16 contusion/superficial injury</td>
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<td>162.17 crushing injury</td>
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<td>163.02 poisoning by specified nonmedicinal substances, injury external causes</td>
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<td>Other Perinatal Problems Affecting Newborn</td>
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### Table A-1 (continued) Hierarchical Condition Categories

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<td>bone marrow transplant (procedure)</td>
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<td>liver transplant (procedure)</td>
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<td>pancreas transplant (procedure)</td>
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174 Major Organ Transplant Status
- 174.01 liver transplant status/complications
- 174.02 heart transplant status/complications
- 174.03 lung transplant status/complications
- 174.04 bone marrow transplant status/complications
- 174.05 pancreas transplant status/complications

175 Other Organ Transplant/Replacement
- 175.01 other organ transplant status/complications
- 175.02 other organ replacement

176 Artificial Openings for Feeding or Elimination
- 176.01 artificial opening of gastrointestinal tract status/complications
- 176.02 other and unspecified artificial opening status
- 176.03 artificial opening of urinary tract status
- 176.04 gastrostomy (procedure)
- 176.05 enterostomy (procedure)
- 176.06 enteral nutrition (DME)
- 176.07 parenteral nutrition (DME)

177 Amputation Status, Lower Limb/Amputation Complications
- 177.01 amputation status (lower limb), amputation complications
- 177.02 amputation, lower limb (procedure)
- 177.03 lower limb prostheses (DME)

178 Amputation Status, Upper Limb
- 178.01 amputation status, upper limb
- 178.02 amputation, upper limb (procedure)
- 178.03 upper limb prostheses (DME)

179 Post-Surgical States/Aftercare/Elective
- 179.01 heart valve replacement status
- 179.02 postsurgical states, eye
- 179.03 joint replacement
- 179.04 other postsurgical states
- 179.05 status cardiac pacemaker, other, and unspecified cardiac device
- 179.06 status automatic implantable cardiac defibrillator
- 179.07 status cerebrospinal fluid drainage device/shunt
- 179.08 elective surgery
- 179.09 prosthesis/other device fitting, adjustment
- 179.10 other orthopedic aftercare
- 179.11 aftercare
- 179.12 donor

180 Radiation Therapy
- 180.01 radiation therapy
- 180.02 radiation therapy (procedure)

181 Chemotherapy
- 181.01 chemotherapy
- 181.02 chemotherapy (procedure)

182 Rehabilitation
- 182.01 rehabilitation procedures

183 Screening/Observation/Special Exams
- 183.01 screening/observation/special exams
- 183.02 vaccination, medical exam, other preventive
- 183.03 administrative/consultation
- 183.04 screening for malignant neoplasm

184 History of Disease
- 184.01 history of malignant neoplasm
- 184.02 history of mental disorder/other disease
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<td>Patient Lifts, Power Operated Vehicles, Beds</td>
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<td>Hospital beds (DME)</td>
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<td>Patient lifts (DME)</td>
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<td>Power operated vehicles (DME)</td>
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<td>Wheelchairs, Commodes</td>
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**SOURCE:** Health Economics Research, Inc.
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<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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<td>498</td>
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<td>9,383</td>
<td>9,537</td>
<td>188</td>
<td>18,252</td>
<td>191</td>
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<tr>
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<td>cancer of kidney and renal pelvis</td>
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<td>9,568</td>
<td>361</td>
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### Table A-2 (continued)

Descriptive Statistics on Prospective DXGs

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<th>DXG</th>
<th>Label</th>
<th>Frequency</th>
<th>1997 Person Years</th>
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<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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<td>555</td>
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<td>1,356</td>
<td>1,276</td>
<td>8,353</td>
<td>497</td>
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<td>neurofibromatosis</td>
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<td>865</td>
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Table A-2 (continued)

Descriptive Statistics on Prospective DXGs

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<th>Label</th>
<th>1997 Mean</th>
<th>Std. Coefficient of Variation</th>
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<td>type II diabetes without complications</td>
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<td>type I diabetes without complications</td>
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<td>type II diabetes without complications</td>
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<td>type I diabetes without complications</td>
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<tr>
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<td>type II diabetes with unspecified complication</td>
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<td>type I diabetes with unspecified complication</td>
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<td>adrenal gland disorders e.g., Cushing's syndrome</td>
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<td>32.24</td>
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<td>non-diabetic hypoglycemic coma</td>
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<td>pituitary dwarfism</td>
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<td>inborn errors of metabolism</td>
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<td>22.05</td>
<td>macroglobulinemia and paraproteinemia, except monoclonal</td>
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<td>hemochromatosis, other disorders of iron, copper, and phosphorus metabolism</td>
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<td>alpha 1-antitrypsin deficiency/hereditary angioedema</td>
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<td>goiter</td>
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<td>congenital hypothyroidism (cretinism)</td>
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<td>other hypoglycemia</td>
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<td>ovarian dysfunction</td>
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<td>other endocrine disorders</td>
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<td>vitamin B/other nutritional deficiencies</td>
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<td>disorders of bilirubin excretion and unspecified metabolism disorders</td>
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<td>23,841</td>
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<td>24.15</td>
<td>other hyperalimentation</td>
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<td>24.16</td>
<td>obesity/localized adiposity</td>
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<td>congenital anomalies of endocrine glands</td>
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<td>esophageal varices</td>
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<td>end stage liver disorders, including hepatic coma and liver failure</td>
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</table>
Table A-2 (continued)
Descriptive Statistics on Prospective DXGs

<table>
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<tr>
<th>DXG</th>
<th>Label</th>
<th>1997 Frequency</th>
<th>1997 Person Years</th>
<th>1997 Mean Expenditures</th>
<th>Std. Err. of the Mean</th>
<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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<td>1,350</td>
<td>1,220</td>
<td>13,380</td>
<td>739</td>
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</tr>
<tr>
<td>28.02</td>
<td>viral hepatitis, acute or unspecified, with hepatic coma</td>
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<td>94</td>
<td>10,383</td>
<td>1,893</td>
<td>18,375</td>
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<td>toxic and other/unspecified non-viral hepatitis/other liver disorders</td>
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<td>14,081</td>
<td>10,776</td>
<td>1,893</td>
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<td>gallstones with gallbladder inflammation and other gallbladder disease</td>
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<td>1,893</td>
<td>18,375</td>
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<td>42,980</td>
<td>6,561</td>
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<td>15,656</td>
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Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: A-23
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<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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### Table A-2 (continued)

**Descriptive Statistics on Prospective DXGs**

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<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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<td>Expenditures</td>
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Table A-2 (continued)

Descriptive Statistics on Prospective DXGs

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<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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Table A-2 (continued)

Descriptive Statistics on Prospective DXGs

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<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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Descriptive Statistics on Prospective DXGs

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<th>Std. Err. of the Mean</th>
<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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Table A-2 (continued)

Descriptive Statistics on Prospective DXGs

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<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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### Table A-2 (continued)

**Descriptive Statistics on Prospective DXGs**

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<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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Table A-2 (continued)
Descriptive Statistics on Prospective DXGs
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<th>1997 Expenditures</th>
<th>Std. Err. of the Mean</th>
<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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<td>abnormality of gait (ataxic, paralytic, spastic, staggering)</td>
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<td>16,171</td>
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<td>ataxia (muscular incoordination), transient limb paralysis</td>
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Table A-2 (continued)

Descriptive Statistics on Prospective DXGs

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<th>DXG</th>
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<th>1997 Frequency</th>
<th>1997 Mean Person Years</th>
<th>1997 Mean Expenditures</th>
<th>Std. Err. of the Mean</th>
<th>Std. Dev.</th>
<th>Coefficient of Variation</th>
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<td>40,994</td>
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<td>lack of expected normal physiological development</td>
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<td>892</td>
<td>27,396</td>
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<td>57,113</td>
<td>10,244</td>
<td>90</td>
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<td>12,963</td>
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<td>1,039</td>
<td>13,000</td>
<td>621</td>
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<td>respiratory distress/insufficiency</td>
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<td>Coefficient of Variation</td>
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Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: A-39
## Table A-2 (continued)

### Descriptive Statistics on Prospective DXGs

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<tr>
<th>DXG</th>
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<th>1997 Person Years</th>
<th>1997 Mean Expenditures</th>
<th>Std. Err. of the Mean</th>
<th>Std. Dev</th>
<th>Coefficient of Variation</th>
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<td>934</td>
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<td>774</td>
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**OUTPUT:** D9pr03cd.out, D9pr04aa.out, D9pr03cd.ou2, and D9pr04aa.ou2.

**SOURCE:** Health Economics Research, Inc. analysis of 1996 and 1997 Medicare data.
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<th>Standard Deviation</th>
<th>Standard Error</th>
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**1997 Medicare Payments**

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<th>1997 Medicare Payments</th>
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<td>viral encephalitis, including acute poliomyelitis, excluding slow virus infection</td>
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<td>3.04</td>
<td>viral meningitis</td>
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<tr>
<td>3.05</td>
<td>late effects of central nervous system infection</td>
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### Notes
- **CV**: Coefficient of Variation
- **Mean** and **Standard Deviation** are calculated from the full sample.
- **1997 Medicare Payments** row shows the total Medicare payments for each DxG category.
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<th>DXG Label</th>
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<th>Standard Error</th>
<th>CV</th>
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<td>obesity/localized adiposity</td>
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<td>chronic pancreatitis/ other pancreatic diseases/intestinal malabsorption</td>
<td>7,417</td>
<td>19,856</td>
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<td>30.07</td>
<td>acute pancreatitis</td>
<td>6,382</td>
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<td>regional enteritis (Crohn's disease), age 18+</td>
<td>3,645</td>
<td>12,565</td>
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<td>inflammatory bowel disease, age &lt; 18</td>
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<td>588</td>
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<td>bacterial enteritis (intestinal infections)</td>
<td>4,237</td>
<td>38,774</td>
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<td>14,429</td>
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<td>gastrointestinal hemorrhage, except peptic ulcer and an/rrectal</td>
<td>58,308</td>
<td>17,842</td>
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<td>30.14</td>
<td>peptic ulcer with hemorrhage, without perforation</td>
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<td>pyloric/duodenal obstruction</td>
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<td>24,308</td>
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<td>29,024</td>
<td>26,695</td>
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<td>38,774</td>
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<td>17,842</td>
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<td>30.26</td>
<td>peptic ulcer with hemorrhage, without perforation</td>
<td>7,805</td>
<td>23,209</td>
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<td>30.27</td>
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<td>19,149</td>
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<td></td>
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<tr>
<td>30.28</td>
<td>pyloric/duodenal obstruction</td>
<td>1,824</td>
<td>24,308</td>
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<tr>
<td>30.29</td>
<td>intestinal obstruction, except hepatic coma and liver failure</td>
<td>29,024</td>
<td>26,695</td>
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<td>chronic pancreatitis/ other pancreatic diseases/intestinal malabsorption</td>
<td>7,417</td>
<td>19,856</td>
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<td>acute pancreatitis</td>
<td>6,382</td>
<td>21,885</td>
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<td>regional enteritis (Crohn's disease), age 18+</td>
<td>3,645</td>
<td>12,565</td>
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<td>ulcerative colitis, age 18+</td>
<td>5,033</td>
<td>12,124</td>
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<tr>
<td>30.34</td>
<td>inflammatory bowel disease, age &lt; 18</td>
<td>1</td>
<td>588</td>
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<td></td>
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<tr>
<td>30.35</td>
<td>bacterial enteritis (intestinal infections)</td>
<td>4,237</td>
<td>38,774</td>
<td></td>
<td></td>
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<tr>
<td>30.36</td>
<td>peptic ulcer not specified as with perforation, hemorrhage, or obstruction</td>
<td>44,499</td>
<td>14,429</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30.37</td>
<td>gastrointestinal hemorrhage, except peptic ulcer and an/rrectal</td>
<td>58,308</td>
<td>17,842</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30.38</td>
<td>peptic ulcer with hemorrhage, without perforation</td>
<td>7,805</td>
<td>23,209</td>
<td></td>
<td></td>
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<tr>
<td>30.39</td>
<td>peptic ulcer with obstruction, without perforation or hemorrhage</td>
<td>1,063</td>
<td>19,149</td>
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<tr>
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<td>pyloric/duodenal obstruction</td>
<td>1,824</td>
<td>24,308</td>
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</tr>
<tr>
<td>30.41</td>
<td>intestinal obstruction, except hepatic coma and liver failure</td>
<td>29,024</td>
<td>26,695</td>
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<td></td>
</tr>
</tbody>
</table>

**Table A-3 (continued)**

Medicare Concurrent Sample Statistics, 1997, by All Diagnosis Diagnostic Groups (DXG)
Medicare Concurrent Sample Statistics, 1997, by All Diagnosis Diagnostic Groups (DXG)

<table>
<thead>
<tr>
<th>DXG Label</th>
<th>1997 Medicare Payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rheumatoid arthritis and other inflammatory polyarthritis</td>
<td>33,460 (8,885, 16,514)</td>
</tr>
<tr>
<td>Inflammatory spondylarthropathies</td>
<td>5,881 (8,334, 15,891)</td>
</tr>
<tr>
<td>Polymyalgia rheumatica</td>
<td>9,223 (8,313, 15,321)</td>
</tr>
<tr>
<td>Spondylitis and allied disorders (osteoarthritis of spine)</td>
<td>58,054 (9,128, 16,122)</td>
</tr>
<tr>
<td>Intervertebral disc disorders (hemiated, prolapsed, degenerated disc)</td>
<td>85,258 (8,472, 15,442)</td>
</tr>
<tr>
<td>Spinal stenosis</td>
<td>30,842 (10,825, 16,919)</td>
</tr>
<tr>
<td>Curve/deformity of the spine</td>
<td>13,171 (10,466, 16,731)</td>
</tr>
<tr>
<td>Spondylolisthesis/spondylolysis, congenital or acquired</td>
<td>8,241 (9,778, 15,744)</td>
</tr>
<tr>
<td>Osteoarthritis of pelvic region and thigh (hip)</td>
<td>28,768 (11,409, 17,539)</td>
</tr>
<tr>
<td>Osteoarthritis of lower leg (knee)</td>
<td>67,856 (9,128, 16,122)</td>
</tr>
<tr>
<td>Osteomalacia/rickets, except vitamin D-resistant</td>
<td>408 (11,073, 21,037)</td>
</tr>
<tr>
<td>Other bone/cartilage disorders (e.g., Paget's disease)</td>
<td>42,451 (11,621, 19,774)</td>
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<tr>
<td>Osteoporosis</td>
<td>89,343 (8,746, 16,110)</td>
</tr>
<tr>
<td>Juvenile osteochondrosis spine/pelvis, slipped capital femoral epiphysis</td>
<td>239 (12,240, 19,946)</td>
</tr>
<tr>
<td>Congenital hip dislocation/dysplasia</td>
<td>248 (18,253, 23,892)</td>
</tr>
<tr>
<td>Osteogenesis imperfecta and other osteodystrophies</td>
<td>624 (12,155, 23,567)</td>
</tr>
<tr>
<td>Marfan and Ehlers-Danlos syndromes</td>
<td>118 (10,078, 26,039)</td>
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<tr>
<td>Reiter's syndrome</td>
<td>96 (10,397, 16,576)</td>
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<tr>
<td>Gout/crystal arthropathy</td>
<td>31,413 (9,233, 17,517)</td>
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<tr>
<td>Psoriatic arthropathy</td>
<td>1,204 (7,188, 12,817)</td>
</tr>
<tr>
<td>Arthropathy/joint disorders, derangements, joint pain/stiffness, excluding gout</td>
<td>294,661 (9,094, 16,803)</td>
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<tr>
<td>Osteoarthritis, not specified to be of spine, hip, or knee</td>
<td>232,149 (7,867, 14,785)</td>
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<tr>
<td>Acquired limb deformities, except toe, flat foot</td>
<td>9,480 (7,188, 12,817)</td>
</tr>
<tr>
<td>Cleft lip/cleft palate</td>
<td>80 (12,943, 21,944)</td>
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<tr>
<td>Other congenital musculoskeletal abnormalities</td>
<td>5,384 (9,201, 17,332)</td>
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<tr>
<td>Osteoarthrosis</td>
<td>3,206 (19,938, 27,771)</td>
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<tr>
<td>Acquired hemolytic anemia</td>
<td>1,438 (24,990, 32,753)</td>
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<td>Acute aplastic anemia</td>
<td>6,113 (30,617, 35,655)</td>
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<td>Aplastic anemia</td>
<td>7,400 (19,020, 37,243)</td>
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<td>Hemophilia (congenital factors VIII and IX coagulation defects)</td>
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<tr>
<td>Acute hematologic and other unspecified anemias</td>
<td>1,204 (7,188, 12,817)</td>
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<tr>
<td>Iron deficiency and other unspecified anemias</td>
<td>36,256 (18,340, 23,377)</td>
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<tr>
<td>Sideroblastic anemia</td>
<td>2,314 (17,832, 25,414)</td>
</tr>
<tr>
<td>Megaloblastic and other unspecified anemias (pernicious/folic acid)</td>
<td>23,111 (18,496, 28,289)</td>
</tr>
<tr>
<td>Acute coagulation defects, except congenital factors VIII and IX</td>
<td>16,406 (21,889, 34,857)</td>
</tr>
<tr>
<td>Purpura/thrombocytopenia/hemorrhagic conditions</td>
<td>2,157 (16,466, 26,442)</td>
</tr>
<tr>
<td>Megaloblastic anemia and other unspecified anemias</td>
<td>2,314 (17,832, 25,414)</td>
</tr>
<tr>
<td>Other and unspecified white blood cell disease, age &lt; 18</td>
<td>8,046 (25,478, 32,593)</td>
</tr>
<tr>
<td>Immune/white blood cell disorders, age &lt; 18</td>
<td>2,469 (9,167, 16,924)</td>
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<tr>
<td>Polycthemia vera</td>
<td>2,469 (9,167, 16,924)</td>
</tr>
<tr>
<td>Thalassemia and other hereditary hemolytic anemias</td>
<td>2,157 (16,466, 26,442)</td>
</tr>
<tr>
<td>Sideroblastic anemia</td>
<td>2,314 (17,832, 25,414)</td>
</tr>
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</tr>
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</tr>
<tr>
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<td>2,314 (17,832, 25,414)</td>
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<tr>
<td>Acute coagulation defects, except congenital factors VIII and IX</td>
<td>23,111 (18,496, 28,289)</td>
</tr>
<tr>
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<td>16,406 (21,889, 34,857)</td>
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<tr>
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<td>8,046 (25,478, 32,593)</td>
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<td>2,469 (9,167, 16,924)</td>
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<tr>
<td>Polycthemia vera</td>
<td>2,469 (9,167, 16,924)</td>
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<td>2,157 (16,466, 26,442)</td>
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<tr>
<td>Sideroblastic anemia</td>
<td>2,314 (17,832, 25,414)</td>
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<td>23,111 (18,496, 28,289)</td>
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<td>Purpura/thrombocytopenia/hemorrhagic conditions</td>
<td>16,406 (21,889, 34,857)</td>
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<td>8,046 (25,478, 32,593)</td>
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<tr>
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<td>2,157 (16,466, 26,442)</td>
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<td>Sideroblastic anemia</td>
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<td>50.02</td>
<td>other/unspecified brain/central nervous system conditions</td>
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<td>senility without psychosis</td>
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<td>50.01</td>
<td>alcoholic psychoses</td>
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<tr>
<td>50.02</td>
<td>drug psychoses</td>
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<tr>
<td>50.02</td>
<td>drug dependence</td>
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<td>53.01</td>
<td>nondependent drug abuse, except alcohol and tobacco</td>
</tr>
<tr>
<td>53.02</td>
<td>nondependent abuse of alcohol</td>
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<tr>
<td>53.03</td>
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<td>schizoaffective disorders</td>
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<td>55.01</td>
<td>manic and depressive (bipolar) disorders</td>
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<td>major depressive disorders</td>
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<td>55.03</td>
<td>paranoid disorders and states</td>
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<td>attempted suicide/self-inflicted injury</td>
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<td>56.01</td>
<td>reactive and other/unspecified nonorganic psychoses</td>
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<td>57.01</td>
<td>personality disorders and dissociative identity disorder</td>
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<td>58.01</td>
<td>depression, excluding major depressive and bipolar disorders</td>
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<tr>
<td>59.01</td>
<td>personality disorders and states</td>
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<tr>
<td>59.02</td>
<td>other and unspecified anxiety states</td>
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<td>59.03</td>
<td>somatoform/dissociative disorders</td>
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<td>other and unspecified anxiety states</td>
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<td>other and unspecified depression</td>
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<td>60.02</td>
<td>other and unspecified anxiety states</td>
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<td>60.03</td>
<td>sexual deviations and disorders</td>
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<td>60.04</td>
<td>psychosomatic illness</td>
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<td>emotional disorders of childhood/adolescence</td>
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<td>60.06</td>
<td>Tourette's disorder</td>
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<td>61.01</td>
<td>profound mental retardation</td>
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<td>Edwards/Patau/deletion/autosomal anomaly syndromes</td>
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<td>moderate mental retardation</td>
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<td>63.01</td>
<td>severe mental retardation</td>
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<td>64.01</td>
<td>autism/pervasive developmental disorders, other childhood psychoses</td>
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<tr>
<td>64.02</td>
<td>anxiety/pervasive developmental disorders, other childhood psychoses</td>
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<tr>
<td>65.01</td>
<td>emotional disorders of childhood/adolescence</td>
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<tr>
<td>65.02</td>
<td>learning/development disorders</td>
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<td>65.03</td>
<td>unspecified chromosomal anomalies and congenital malformation syndromes, nec</td>
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<td>65.04</td>
<td>sex chromosome abnormalities (e.g., Klinefelter's/ Turner syndromes)</td>
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<td>66.01</td>
<td>attention deficit disorder, other hyperkinetic syndrome</td>
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<tr>
<td>67.01</td>
<td>motor neuron disease (including ALS) and spinal muscular atrophy</td>
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<td>67.02</td>
<td>congenital/infantile quadriplegia (cerebral palsy)</td>
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<tr>
<td>67.03</td>
<td>quadriplegia, incomplete or unspecified</td>
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<tr>
<td>67.04</td>
<td>quadriplegia (C1-C7), complete</td>
</tr>
<tr>
<td>67.05</td>
<td>locked-in state</td>
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<tr>
<td>67.06</td>
<td>traumatic complete lesion cervical (C1-C7) spinal cord</td>
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<tr>
<td>67.07</td>
<td>congenital/infantile diplegia/ paraplegia (cerebral palsy)</td>
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<tr>
<td>67.08</td>
<td>paraplegia</td>
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<td>67.09</td>
<td>traumatic complete lesion dorsal (T1-T12) spinal cord</td>
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<tr>
<td>67.15</td>
<td>other and unspecified spinal cord disease</td>
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<td>67.16</td>
<td>other and unspecified spinal cord disease</td>
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<tr>
<td>67.17</td>
<td>other and unspecified spinal cord disease</td>
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Table A-3 (continued)
Medicare Concurrent Sample Statistics, 1997, by All Diagnosis Diagnostic Groups (DXG)

DXG

DXG Label

69.10
70.01
70.02
71.01
71.02
71.03
71.04
71.05
72.01
73.01
73.02
74.01
74.02
74.03
75.01
75.02
75.03
76.01
76.02
76.03
76.04
76.05
76.06
76.07
76.08
76.09
76.10
76.11
76.12
76.13
77.01
77.02
77.03
77.04
78.01
79.01
79.02
79.03
79.04
80.01
80.02
80.03
80.04
80.05
81.01
82.01
82.02
82.03
83.01
83.02
84.01
84.02
85.01
85.02
85.03
86.01
86.02
86.03
86.04
86.05
86.06
87.01
87.02
88.01

severe cervical/dorsal spinal cord injury w/o vertebral fracture, exc compl lesion
muscular dystrophy, age 18+
muscular dystrophy, age < 18
autonomic nerve disorder
peripheral neuropathy/myopathy
inflammatory/toxic neuropathy, except diabetic
diabetic neuropathy
myoneural disorders/myasthenia gravis
multiple sclerosis, other central nervous system dymelination
Parkinson's disease
Huntington's and degenerative disease of basal ganglia
epilepsy, age 18+
convulsions, except febrile
epilepsy, age < 18
brain anoxic damage, edema, and compression (nontraumatic)
coma, nontraumatic
persistent vegetative state
postherpetic neuralgia/other neurological complications of herpes zoster
essential tremor and other abnormal movement disorders
migraine headaches
trigeminal nerve disorders
facial nerve disorders, including Bell's Palsy
other cranial nerve disorders
root/plexus disorders
other specified neuropathy
root/plexus lesions
neuropathy of upper limb (e.g., carpal tunnel syndrome)
neuropathy of leg
abnormal involuntary movements nec (e.g. spasms/tremor nos)
nerve injury, excluding spinal cord and brain
tracheostomy status/complications
respirator dependence
tracheostomy (procedure)
ventilator (DME)
respiratory arrest
cardiac arrest/shock
acute lung edema nos
post trauma/surgery pulmonary insufficiency, incl adult respir distress syndr
respiratory failure
hypertensive heart disease, with heart failure
hypertensive heart/renal disease, with heart failure
pulmonary vascular disease, except pulmonary embolism
cardiomyopathy/myocarditis
heart failure
acute myocardial infarction, initial episode of care
myocardial infarction, subsequent episode of care, or unspecified
unstable angina and other acute ischemic heart disease
postmyocardial infarction syndrome
old myocardial infarction
angina pectoris
coronary atherosclerosis and other chronic ischemic heart disease
aneurysm and other congenital abnormalities of coronary artery
acute endo/myocarditis
pericarditis and other diseases of pericardium
cardiovascular syphilis
rheumatic fever/heart disease
mitral or aortic valve/endocardia disease
mitral/aortic valve disorders
rheumatic heart failure
congenital abnormalities of heart valves
aortic atresia/stenosis and other congenital aortic abnormalities
major congenital cardiac/circulatory system abnormality, age 18+
major congenital cardiac/circulatory defect, age < 18
other and unspecified congenital cardiac/circulatory system abnormality

Health Economics Research, Inc.

Number of
Person-Years
101
608
.
4,892
21,519
4,078
8,355
1,634
4,774
21,717
1,133
13,076
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2,120
1,960
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12,230
14,091
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4,149
783
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2,301
1,777
19,099
20,036
8,887
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773
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35,182
167,393
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4,894
480
13,306
106,610
21,810
1,106
4,648
3,350
326
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7,506

1997 Medicare Payments
Standard Standard
Mean Deviation Error
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15,931
22,160
15,010
12,315
12,626
15,174
14,171
15,646
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44,935
40,308
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18,133

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27,630
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30,201
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20,533
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50,545
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25,881
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27,051
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36,800
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28,036

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987
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360
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458
297
881
324
140
675
229
142
40,549
1,117
1,229
3,224
287
190
132
247
290
863
526
377
469
106
134
227
374
1,982
2,961
.
.
946
365
556
965
226
232
961
235
147
65
222
202
109
796
119
70
38
304
1,352
555
1,332
224
75
179
1,088
397
486
2,038
.
324

134
183
.
141
180
184
123
237
182
163
150
185
174
141
112
121
136
178
191
197
186
178
163
178
193
219
194
189
181
156
114
86
.
.
106
114
108
103
122
146
121
135
145
151
104
120
124
118
128
151
174
159
137
133
162
131
159
141
105
161
150
159
.
155

DCG/HCC Models for Medicare Risk Adjustment: A-46


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<tr>
<th>DXG</th>
<th>DXG Label</th>
<th>Number of Person-Years</th>
<th>1997 Medicare Payments</th>
</tr>
</thead>
<tbody>
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<td>ventricular septal defect</td>
<td>520</td>
<td>16,797 32,064 1,460 191</td>
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<tr>
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<td>atrial septal defect</td>
<td>648</td>
<td>19,906 34,431 1,353 173</td>
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<tr>
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<td>situs inversus/Kartagener's syndrome</td>
<td>218</td>
<td>9,475 18,646 1,263 197</td>
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<tr>
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<td>hypertensive renal disease, without renal failure</td>
<td>4,063</td>
<td>19,543 29,268 459 150</td>
</tr>
<tr>
<td>89.02</td>
<td>hypertensive heart and renal disease, w/o heart or renal failure</td>
<td>2,575</td>
<td>11,653 20,701 408 178</td>
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<tr>
<td>89.03</td>
<td>hypertension encephalopathy</td>
<td>1,133</td>
<td>18,858 28,948 799 154</td>
</tr>
<tr>
<td>90.01</td>
<td>hypertensive heart disease, without heart failure</td>
<td>66,393</td>
<td>7,490 15,920 20 213</td>
</tr>
<tr>
<td>90.02</td>
<td>malignant hypertensive heart disease, without heart failure</td>
<td>6,958</td>
<td>9,780 19,993 240 204</td>
</tr>
<tr>
<td>91.01</td>
<td>essential hypertension</td>
<td>631,468</td>
<td>7,490 15,920 20 213</td>
</tr>
<tr>
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<td>malignant hypertension</td>
<td>35,387</td>
<td>9,845 18,947 101 192</td>
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<td>secondary hypertension</td>
<td>789</td>
<td>18,389 25,578 271 139</td>
</tr>
<tr>
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<td>18,389 25,578 271 139</td>
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<td>atrial arrhythmia</td>
<td>122,485</td>
<td>15,792 25,996 74 165</td>
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<td>26,596 34,247 301 129</td>
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<tr>
<td>92.04</td>
<td>sinoatrial node dysfunction, including sick sinus syndrome</td>
<td>24,877</td>
<td>16,180 23,380 150 155</td>
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<tr>
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<td>other conduction disorders/cardiac dysrhythmias</td>
<td>131,807</td>
<td>14,705 23,380 64 159</td>
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<tr>
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<td>second degree heart block</td>
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<td>21,504 26,369 470 123</td>
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<td>premature heart beats</td>
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<td>18,389 25,578 271 139</td>
</tr>
<tr>
<td>94.02</td>
<td>other and unspecified heart disease</td>
<td>2,253</td>
<td>18,389 25,578 271 139</td>
</tr>
<tr>
<td>94.03</td>
<td>cardiomegaly (enlarged heart)</td>
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<td>18,389 25,578 271 139</td>
</tr>
<tr>
<td>95.01</td>
<td>cerebral hemorrhage</td>
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<td>18,389 25,578 271 139</td>
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<tr>
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<td>18,663 26,520 104 142</td>
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<tr>
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<td>cerebrovascular accident, unspecified</td>
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<td>9,780 19,993 240 204</td>
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Health Economics Research, Inc.  
DCG/HCC Models for Medicare Risk Adjustment: A-47
Table A-3 (continued)

Medicare Concurrent Sample Statistics, 1997, by All Diagnosis Diagnostic Groups (DXG)

<table>
<thead>
<tr>
<th>DXG</th>
<th>DXG Label</th>
<th>Number of Person-Years</th>
<th>1997 Medicare Payments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
</tr>
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<td>noninfectious lymphatic disorders</td>
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<td>hypotension</td>
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<td>25,075</td>
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<td>other circulatory disease/postphlebitic syndrome</td>
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<td>20,276</td>
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<td>hemorrhage nos</td>
<td>2,275</td>
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<td>compression of vein</td>
<td>2,560</td>
<td>21,786</td>
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<tr>
<td>106.12</td>
<td>other specified circulatory disorders</td>
<td>25,075</td>
<td>15,912</td>
</tr>
<tr>
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<td>cystic fibrosis, age 18+</td>
<td>457</td>
<td>8,159</td>
</tr>
<tr>
<td>106.08</td>
<td>cystic fibrosis, age &lt; 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>107.01</td>
<td>emphysema/chronic bronchitis</td>
<td>192,897</td>
<td>13,327</td>
</tr>
<tr>
<td>107.02</td>
<td>chronic obstructive asthma</td>
<td>13,782</td>
<td>17,952</td>
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<tr>
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<td>sarcoidosis</td>
<td>1,274</td>
<td>11,130</td>
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<td>107.04</td>
<td>bronchiectasis</td>
<td>3,720</td>
<td>18,075</td>
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<td>107.05</td>
<td>other specified lung infections, except candida</td>
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<td>27,431</td>
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<td>viral pneumonia</td>
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<tr>
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<td>18,952</td>
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<td>congenital lung/respiratory anomaly</td>
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<td>43,390</td>
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<td>blind, WHO or USA legal definition</td>
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<td>16,031</td>
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<td>corneal ulcer/abcess</td>
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<td>retinal detachment</td>
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<td>7,030</td>
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<td>proliferative diabetic retinopathy</td>
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<td>12,109</td>
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<td>vitreous hemorrhage</td>
<td>3,842</td>
<td>10,499</td>
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<td>diabetic retinopathy</td>
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<td>10,917</td>
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<td>107.21</td>
<td>vascular retinopathies, except diabetic</td>
<td>27,353</td>
<td>7,324</td>
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<tr>
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<td>retinal hemorrhage, edema</td>
<td>11,924</td>
<td>8,061</td>
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<td>retinal defects without detachment</td>
<td>3,836</td>
<td>5,368</td>
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<td>107.24</td>
<td>other and unspecified retinal disorders</td>
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<td>6,139</td>
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<td>macular degeneration</td>
<td>108,571</td>
<td>6,051</td>
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<td>retinitis pigmentosa, other hereditary retinal dystrophies</td>
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<td>5,925</td>
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<tr>
<td>107.27</td>
<td>and unspecified glaucoma</td>
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<td>10,438</td>
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<td>107.28</td>
<td>glaucoma</td>
<td>55,208</td>
<td>4,740</td>
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<tr>
<td>107.29</td>
<td>open-angle glaucoma</td>
<td>91,866</td>
<td>5,585</td>
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<td>107.30</td>
<td>primary angle-closure glaucoma, non-acute or unspecified</td>
<td>5,720</td>
<td>5,836</td>
</tr>
<tr>
<td>107.31</td>
<td>acute primary angle-closure glaucoma</td>
<td>1,732</td>
<td>6,959</td>
</tr>
<tr>
<td>107.32</td>
<td>cataract</td>
<td>396,623</td>
<td>5,264</td>
</tr>
<tr>
<td>107.33</td>
<td>diabetic cataract</td>
<td>485</td>
<td>9,814</td>
</tr>
<tr>
<td>107.34</td>
<td>disorders of the optic nerve and visual pathways, including optic neuritis</td>
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<td>7,819</td>
</tr>
<tr>
<td>107.35</td>
<td>uveitis</td>
<td>7,814</td>
<td>6,865</td>
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<tr>
<td>107.36</td>
<td>other and unspecified eye disorders</td>
<td>277,293</td>
<td>5,870</td>
</tr>
<tr>
<td>107.37</td>
<td>disorders of refraction and accommodation</td>
<td>51,811</td>
<td>4,536</td>
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<tr>
<td>107.38</td>
<td>visual loss, one eye or unspecified</td>
<td>3,888</td>
<td>9,285</td>
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<tr>
<td>107.39</td>
<td>visual loss, both eyes</td>
<td>1,144</td>
<td>9,331</td>
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<tr>
<td>107.40</td>
<td>keratoconus</td>
<td>461</td>
<td>4,870</td>
</tr>
</tbody>
</table>
### Table A-3 (continued)

**Medicare Concurrent Sample Statistics, 1997, by All Diagnosis Diagnostic Groups (DXG)**

<table>
<thead>
<tr>
<th>DXG</th>
<th>DXG Label</th>
<th>Number of Person-Years</th>
<th>1997 Medicare Payments</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>CV</th>
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</thead>
<tbody>
<tr>
<td>124.08</td>
<td>congenital anomalies of eye</td>
<td>3,622</td>
<td>6,040</td>
<td>13,163</td>
<td>219</td>
<td>218</td>
<td></td>
</tr>
<tr>
<td>124.09</td>
<td>open wound of ocular adnexa, foreign body on external eye, burn eye/adnexa</td>
<td>5,827</td>
<td>6,680</td>
<td>13,830</td>
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<td>207</td>
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<tr>
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<td>open wound of eyeball, including penetrating foreign body</td>
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<td>9,812</td>
<td>15,702</td>
<td>590</td>
<td>160</td>
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<td>perichondritis of pinna</td>
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<td>6,549</td>
<td>13,202</td>
<td>398</td>
<td>202</td>
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<tr>
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<td>malignant otitis externa</td>
<td>84</td>
<td>10,252</td>
<td>19,748</td>
<td>2,150</td>
<td>193</td>
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<td>8,216</td>
<td>18,033</td>
<td>412</td>
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<td>10,742</td>
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<tr>
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<td>larynx/vocal cord diseases</td>
<td>5,500</td>
<td>11,641</td>
<td>23,288</td>
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<tr>
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<td>25,250</td>
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<td>1,067</td>
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<td>hearing loss</td>
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<td>7,116</td>
<td>14,576</td>
<td>67</td>
<td>205</td>
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</tr>
<tr>
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<td>other ear disorders</td>
<td>51,519</td>
<td>6,164</td>
<td>13,448</td>
<td>59</td>
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<td></td>
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<td>impacted earex</td>
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<td>217</td>
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<td>8,669</td>
<td>17,773</td>
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<td>769</td>
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<td>38,334</td>
<td>38,562</td>
<td>1,077</td>
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<td>130.02</td>
<td>dialysis (procedure)</td>
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<td>130.03</td>
<td>dialysis supplies and equipment (DME)</td>
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<td>hypertensive renal disease, with renal failure</td>
<td>6,823</td>
<td>32,722</td>
<td>35,669</td>
<td>432</td>
<td>109</td>
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<td>hypertensive heart/renal disease, with renal failure</td>
<td>622</td>
<td>28,090</td>
<td>33,060</td>
<td>1,325</td>
<td>118</td>
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<td>acute renal failure</td>
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<td>43,944</td>
<td>48,448</td>
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<td>110</td>
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<tr>
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<td>chronic renal failure</td>
<td>13,120</td>
<td>28,090</td>
<td>33,060</td>
<td>1,325</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>131.05</td>
<td>renal failure, unspecified</td>
<td>13,105</td>
<td>8,669</td>
<td>17,773</td>
<td>155</td>
<td>205</td>
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<tr>
<td>131.06</td>
<td>other oral soft tissue/bone/jaw disorders</td>
<td>12,047</td>
<td>9,353</td>
<td>19,650</td>
<td>79</td>
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<td>congenital anomalies of ear, face, neck, nose, mouth, and pharynx</td>
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<td>10,300</td>
<td>24,967</td>
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<td>foreign body ear/nose/pharynx/larynx</td>
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<tr>
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<td>nephritis</td>
<td>7,968</td>
<td>24,169</td>
<td>32,301</td>
<td>362</td>
<td>134</td>
<td></td>
</tr>
<tr>
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<td>hydronephrosis, bladder/ureter, other urinary tract obstruction</td>
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<td>19,327</td>
<td>143</td>
<td>175</td>
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<td>1,522</td>
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<td>neurogenic bladder</td>
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<td>136</td>
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### Medicare Concurrent Sample Statistics, 1997, by All Diagnosis Diagnostic Groups (DXG)

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<th>Standard Deviation</th>
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Table A-3 (continued)

Medicare Concurrent Sample Statistics, 1997, by All Diagnosis Diagnostic Groups (DXG)

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Health Economics Research, Inc.

DCG/HCC Models for Medicare Risk Adjustment: A-51
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<th>Standard Error</th>
<th>CV</th>
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### Medicare Concurrent Sample Statistics, 1997, by All Diagnosis Diagnostic Groups (DXG)

#### Table A-3 (continued)

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<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
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**NOTE:** Based on program d9cn03cd.

**SOURCE:** Health Economics Research, Inc.