Possible Effect of DRGs on the Classification of Stroke
Implications for Epidemiological Surveillance

Carol A. Derby, PhD; Kate L. Lapane, PhD; Henry A. Feldman, PhD; Richard A. Carleton, MD

Background and Purpose—Accurate data on the distribution of stroke subtypes are essential for understanding the forces driving recent morbidity and mortality trends. The introduction of diagnosis-related groups (DRGs) in the 1980s may have affected the distribution of stroke subtypes as defined by International Classification of Diseases, Ninth Revision (ICD-9), discharge diagnosis codes.

Methods—The Pawtucket Heart Health Program cardiovascular surveillance data were used to examine trends in stroke classification for 1980 to 1991 in relation to the introduction of DRGs in 2 communities in Massachusetts and Rhode Island, where DRGs were implemented 2 years apart. Included were all hospital discharges for residents aged 35 to 74 with a primary ICD-9 diagnosis of 431 to 432, 434, or 436 to 437 (N = 1386 in Rhode Island, N = 1839 in Massachusetts).

Results—In each state, concurrently with the introduction of DRGs, the proportion of strokes classified as cerebral occlusion (ICD-9 434.0 to 434.9) increased, and the proportion classified as acute but ill-defined (ICD-9 436.0 to 436.9) decreased. Before DRGs, 30.0% of strokes in Rhode Island and 26.6% in Massachusetts were classified as cerebral occlusion, whereas 51.8% in Rhode Island and 51.7% in Massachusetts were classified as acute ill defined. After DRGs were introduced, the proportions of cerebral occlusion and acute, ill-defined stroke, respectively, were 70.9% and 8.5% in Rhode Island and 74.1% and 7.7% in Massachusetts (χ2, all P < 0.001). The proportions of strokes classified as intracerebral hemorrhage or transient cerebral ischemia remained constant.

Conclusions—The implementation of DRGs may have influenced coding of strokes to the ICD-9. Findings highlight the limitations of hospital discharge data for evaluating stroke subtypes and demonstrate the need for community-based surveillance for monitoring specific trends in stroke. (Stroke. 2001;32:1487-1491.)

Key Words: cerebrovascular disorders ■ diagnostic-related groups ■ population surveillance ■ stroke

National data and studies within communities have consistently demonstrated declining mortality from stroke in the United States beginning in the 1960s.1–5 Although mortality has continued to decline, there is evidence that morbidity rates may have stabilized or even increased beginning in the 1980s.1,2,5–9 Although the patterns of stroke over time have been consistent across studies, the forces driving these trends are complex and remain a topic of debate, with the relative contributions of primary and secondary prevention, advances in diagnostic and treatment technologies, and changes in diagnosis and classification unclear.7,9,10

Reliable data on the distribution of stroke subtypes provide essential information for determining the forces driving these trends. However, most available data rely on hospital discharge diagnoses, which may be influenced by trends in hospital reimbursement, coding, and classification, as well as by changes in the natural history of a disease.11–13 In particular, the introduction of diagnosis-related groups (DRGs) in the 1980s may have influenced the distribution of stroke subtypes as defined by International Classification of Diseases, Ninth Revision (ICD-9), discharge codes.10,13,15,16

The Pawtucket Heart Health Program (PHHP) morbidity and mortality surveillance system provided a unique opportunity to examine the impact of DRGs on the classification of stroke subtypes by using hospital discharge information as well as validated stroke rates for 2 cities in states where DRGs were introduced 2 years apart.

Methods

The Pawtucket Heart Health Program

The PHHP was a community demonstration project conducted between 1980 and 1992 to evaluate whether a comprehensive program of community-based health education produced favorable changes in risk factor levels and the occurrence of coronary heart disease and stroke.17,18 The study included 2 communities in southeastern New England, Pawtucket, Rhode Island, the intervention community, and a comparison city in Massachusetts that had similar...

<table>
<thead>
<tr>
<th></th>
<th>Pawtucket, RI</th>
<th>Comparison City, Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-DRG</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dates</td>
<td>1/1/80 to 9/30/83</td>
<td>1/1/80 to 9/30/85</td>
</tr>
<tr>
<td>n</td>
<td>253</td>
<td>665</td>
</tr>
<tr>
<td><strong>Post-DRG</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dates</td>
<td>10/1/83 to 12/31/91</td>
<td>10/1/85 to 12/31/91</td>
</tr>
<tr>
<td>n</td>
<td>611</td>
<td>595</td>
</tr>
<tr>
<td><strong>Total population</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>71,204</td>
<td>98,478</td>
</tr>
<tr>
<td>1990</td>
<td>72,788</td>
<td>99,922</td>
</tr>
<tr>
<td><strong>Mean age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>34 y</td>
<td>34 y</td>
</tr>
<tr>
<td>1990</td>
<td>36 y</td>
<td>37 y</td>
</tr>
<tr>
<td><strong>Percent female</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>53%</td>
<td>54%</td>
</tr>
<tr>
<td>1990</td>
<td>53%</td>
<td>53%</td>
</tr>
</tbody>
</table>

**Case Identification and Validation**

Potential cases were identified from hospital discharge tapes from the 7 hospitals in Rhode Island and Massachusetts that serve the study communities. On the basis of data from the state hospital associations, these hospitals were estimated to provide 96% coverage of care for residents of the study communities. The analysis includes all discharges for a resident of a study community, aged 35 to 74 years, with a primary ICD-9 discharge diagnosis code of 431 (intracerebral hemorrhage), 432 (other unspecified cerebral hemorrhage), 434 (occlusion of cerebral arteries), 436 (acute, ill-defined cerebrovascular disease), or 437 (other ill-defined cerebrovascular disease).

For each eligible case, portions of the medical record were copied, including the discharge summary, CT and/or MRI scans, neurology consultations, and autopsy reports. The study physician then reviewed all available information to determine an outcome of definite stroke, probable stroke, no ascertainable stroke, or inadequate information. This classification was based on whether (1) the clinical description was consistent with a new, localized neurological deficit involving the hemispheres, brain stem, and/or the cerebellum and (2) whether there was evidence for intracerebral hemorrhage with or without intraventricular extension and with or without subarachnoid extension. The following criteria were considered exclusions from the categories of definite or probable stroke: (1) exclusively subarachnoid hemorrhage; (2) cerebral infarction related to rheumatic mitral stenosis or infective endocarditis, or stroke in the presence of prosthetic cardiac valves; (3) exclusively transient ischemic attack; and (4) evidence from the medical history that the hospitalization was for a previous stroke.

**Population Estimates for Calculation of Event Rates**

Midyear population estimates by sex, age, and city were prepared for each of the years 1980 to 1991 by using standard demographic techniques. The cohort-component method was used to take single-year age groups created from the 1980 US Census and project them forward 1 year at a time by using national survival rates provided by the US Bureau of the Census. Births were added for each year by using information obtained from the Departments of Vital Statistics reports of Rhode Island and Massachusetts. Finally, the population estimates were corrected for immigration and outmigration by using estimates based on the 1980 census data and corrected to the 1990 census.

**Statistical Methods**

The dependent variable in each analysis was an event rate per 10,000 population per year, calculated for a single calendar quarter and a single city. Because previous analyses have demonstrated that the age and sex distributions of the population remained stable across the decade studied, data were aggregated by age and sex. The rate was constructed by counting the number of recorded events in the appropriate time period and city, multiplying by 4 to obtain an annualized count, and dividing by a separately determined estimate of population (in 10,000s) in that city for that time period. The unit of analysis was thus a group defined by time and location, and the total sample size for each specific event rate for the 12-year study was 48 (quarters) for each city. In secondary analyses, the data were stratified by age (35 to 64 years and 65 to 74 years), and the strata were analyzed separately.

In exploratory analysis, the outcome variables with higher event rates showed proportionally higher fluctuations from quarter to quarter, similar to the variability of a Poisson-distributed random deviate. The rates were therefore square-root transformed for analysis to homogenize the residual variance across subgroups. After analysis, adjusted mean square-root rates were converted back to natural units for presentation. The transformed rates were analyzed separately for each city by segmented linear regression with independent variables representing time and period (pre/post DRG). The pre-DRG periods in Rhode Island and Massachusetts were defined as January 1, 1980 to September 30, 1983 and January 1, 1980 to September 30, 1985, respectively.

To test the null hypothesis that the time trend in a particular stroke subtype and city did not change with the advent of DRGs, we compared 2 regression models. In the first model, a single time trend was applied across the entire study period (46 degrees of freedom). In the second model, the slope and intercept were allowed to differ between pre- and post-DRG periods (44 degrees of freedom). The 2 models were compared by Fisher’s F test ($df=2, 44$). A statistically significant result indicated that the trends before and after DRGs were different.

**Results**

A total of 2124 discharges met study inclusion criteria, with a primary ICD-9 discharge code of 431, 432, 434, or 436 to 437. Record review was completed for 97% of these cases, of which 80% were confirmed definite or probable strokes. Table 1 displays the numbers of cases in the pre- and post-DRG periods for each state. There was no evidence for a differential trend in rates of total stroke (ICD-9 431 to 432, 434, 436 to 437) in the pre- and post-DRG periods in either state (Figure 1). This pattern was similar for rates of validated stroke.

Although the total stroke rates remained constant over the period, the distribution of stroke categories shifted, such that the rates of stroke coded as cerebral artery occlusion (ICD-9 434) increased while the rates of ill-defined cerebrovascular disease (ICD-9 436) decreased in both states (Table 2). Prior to DRGs, 30% of strokes in Rhode Island and 26.6% of strokes in Massachusetts were classified as cerebral artery occlusion (ICD-9 code 434). After the introduction of DRGs, the proportion of cases classified as cerebral occlusion increased to 70.9% in Rhode Island and to 74.1% in Massa-
chussetts. In contrast, the proportion of strokes classified as ill-defined declined in both states, from 51.8% to 8.5% in Rhode Island and from 51.7% to 7.7% in Massachusetts. The proportions of stroke classified as cerebral hemorrhage (ICD-9 431 or 432) remained fairly constant in the pre- and post-DRG periods. Figure 2 displays the rates of cerebral artery occlusion (ICD-9 434) and of ill-defined cerebrovascular disease (ICD-9 436) across the study period. In Massachusetts, the trends in rates were significantly different in the pre- and post-DRG periods (\( P<0.001 \)). A similar pattern was observed in Rhode Island, although the difference in trends did not reach statistical significance.

Given that DRGs were instituted as part of the Medicare reimbursement system, any influence of DRGs on coding practices would be expected to be most apparent among patients aged 65 or more years. To test this hypothesis, cases were stratified according to age 35 to 64 years or 65 to 74 years, and the rates of cerebral occlusion and of ill-defined stroke subtypes, with an increase in classification as the more specific category of cerebral artery occlusion and a concomitant decline in the use of the category “ill-defined” stroke. These results are consistent with data from the National Hospital Discharge Survey, which also show an increase in the rate of occlusion of the cerebral arteries (ICD-9 434) and a decrease in the rate of acute, ill-defined cerebrovascular disease in the mid-1980s, when DRGs were introduced.

Although ICD-9 coding and assignment of DRGs are theoretically separate processes, these data suggest that the implementation of DRGs may have influenced the coding of stroke subtypes, with an increase in classification as the more specific category of cerebral artery occlusion and a concomitant decline in the use of the category “ill-defined” stroke. These results are consistent with data from the National Hospital Discharge Survey, which also show an increase in the rate of occlusion of the cerebral arteries (ICD-9 434) and a decrease in the rate of acute, ill-defined cerebrovascular disease in the mid-1980s, when DRGs were introduced.

Reimbursement for DRGs is determined by assigning a standard cost weight to each DRG and multiplying this weight by a standard cost, which is adjusted for institutional characteristics. The higher the cost weight for a DRG, the greater is the hospital reimbursement. Simborg introduced the concept of “DRG creep” to describe the potential for the prospective payment system to prompt a systematic shift in discharge coding toward diagnoses with increased severity and to those with higher cost weights. However, the codes examined in this analysis are all included under a single prospective payment category, DRG 14. Thus, financial incentives, or DRG creep, do not appear to explain the observed classification shift.

The introduction of DRGs may have prompted a generalized shift toward more accurate and specific discharge coding as hospitals sought to maximize reimbursement. Previous studies have demonstrated that a high proportion of stroke cases coded as unspecified actually have an etiology identified in the


<table>
<thead>
<tr>
<th>State, period</th>
<th>431</th>
<th>432</th>
<th>434</th>
<th>436</th>
<th>437</th>
<th>Total N</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI Pre-DRG</td>
<td>11.5</td>
<td>1.6</td>
<td>30.0</td>
<td>51.8</td>
<td>5.1</td>
<td>253</td>
</tr>
<tr>
<td>Post-DRG</td>
<td>12.6</td>
<td>0.8</td>
<td>70.9</td>
<td>8.5</td>
<td>7.2</td>
<td>611</td>
</tr>
<tr>
<td>Mass Pre-DRG</td>
<td>8.6</td>
<td>2.7</td>
<td>26.6</td>
<td>51.7</td>
<td>10.4</td>
<td>665</td>
</tr>
<tr>
<td>Post-DRG</td>
<td>11.4</td>
<td>1.3</td>
<td>74.1</td>
<td>7.7</td>
<td>5.4</td>
<td>595</td>
</tr>
</tbody>
</table>
In a review of stroke registries, Yip et al.\(^2\) found that the higher the relative incidence of stroke with undetermined subtype, the lower the rate of stroke classified as large-artery atherosclerotic type. Goldstein et al.\(^2\) reported that nearly half of the cases assigned a code for acute, ill-defined cerebrovascular disease had a discharge summary that included an established etiology. Similarly, studies by Ellekjaer et al.\(^2\) and by Leibson et al.\(^1\) have reported that discharge diagnoses tend to overestimate the proportion of strokes classified as unspecified relative to that obtained when a neurologist reviews the chart. In the Rochester Stroke Registry for the period 1980 to 1989, 29% of all confirmed strokes were assigned ICD-9 code 436, “acute but ill-defined cerebrovascular disease.” However, a neurologists’ review indicated that only 10% of these cases lacked sufficient information to be assigned to a specific type.\(^1\) Thus, the observed classification shift in the PHHP database may be the result of increased coding specificity and accuracy prompted by the introduction of DRGs.
The results of age-stratified analyses suggest that the advent of DRGs brought about a general increase in the specificity of discharge coding for stroke regardless of Medicare status. The trend toward increased use of the more specific ICD-9 codes and decreased use of code 436 occurred even among patients aged 35 to 64, particularly in Massachusetts. Given that medical records staff are unlikely to apply separate coding practices according to age or Medicare status, educational activities and training prompted by DRGs may have influenced all discharge coding. This concept is consistent with prior analyses demonstrating potential DRG-related shifts in discharge coding for ischemic heart disease in this population, regardless of Medicare status.12

During this period, the use of CT scans and MRI for stroke patients increased dramatically in the study communities and nationally.5,20,30 Thus, it is possible that a shift toward more specific coding of strokes resulted from the availability of improved diagnostics. However, the proliferation of these diagnostic technologies and the increase in the proportion of cases with neurology consults began in the pre-DRG period, and the rate of increase showed signs of slowing in the mid-1980s. Both states are likely to have been influenced similarly by advances in diagnostics, yet the “bump” in classification in the 2 states was offset by 2 years, corresponding to the lag in the introduction of DRGs. Finally, analyses that adjusted for the prevalence of CT or MRI did not alter our results.

The present study did not ascertain information on strokes in person over the age of 74. Thus, given the increase in stroke rates with age, many stroke patients are likely to have been excluded. However, because we were able to demonstrate that the observed change in coding was consistent across age groups, the lack of data from older age groups is not likely to have affected the validity of our conclusions.

Increased information regarding the pathophysiology of stroke subtypes would be beneficial for prevention strategies and would provide useful information regarding the forces driving recent morbidity and mortality trends. Although shifts within the broader category of stroke are not likely to influence overall statistics for total stroke, the observed shifts highlight the limitations of hospital discharge data for documenting trends in stroke subtypes. In the present study, an examination of ICD-9 code 434 alone would suggest an increasing rate of stroke resulting from cerebral occlusion. However, the concomitant decline in the rate of unspecified stroke together with the relatively stable total stroke rates suggests that a classification shift rather than a shift in the natural history underlies the trend. These results add to the body of knowledge illustrating the limitations of hospital discharge data for monitoring stroke trends and highlight the need for standardized stroke surveillance databases.

References
Possible Effect of DRGs on the Classification of Stroke: Implications for Epidemiological Surveillance

Carol A. Derby, Kate L. Lapane, Henry A. Feldman and Richard A. Carleton

*Stroke*. 2001;32:1487-1491
doi: 10.1161/01.STR.32.7.1487

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2001 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/32/7/1487

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Stroke* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Stroke* is online at:
http://stroke.ahajournals.org//subscriptions/