Changes in Risk Factors and Hospital Cost of Stroke Care Among California Elderly Over Four Years, 2007-2010

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Abstract

Objective: We examined variations in the prevalence of stroke, associated factors, and hospital costs among California elderly patients over the years 2007 to 2010 by race, ethnicity, and sex.

Methods: California Hospital Discharge Data Files (HDDS) for patients aged 65+ with a diagnosis of stroke (ICD9 codes 430 - 438) were examined in the year 2007 (n = 13,027); 2008 (n = 12,676); 2009 (n = 11,521) and 2010 (n = 7845). Mean age of the study population was about 80 years, females 56%. Data were segregated by sex, race and ethnicity across different sub-populations. Differences between Stroke and Non-Stroke patients as well as the prevalence of stroke and risk factors by race, ethnicity, and sex were evaluated.

Results: Stroke prevalence declined by 40% from 6.3% in 2007 to 4.5% in 2010. Further, during this period, prevalence was higher among females than males and was higher in blacks compared to other race/ethnic groups. Seven (7) established risk factors were consistently associated with stroke including: Depression (OR = 1.10 in 2007, OR = 1.10 in 2008, OR = 1.10 in 2009, and OR = 1.18 in 2010), hypertension (OR = 2.10, OR = 2.32, OR = 2.22, and OR = 1.51), diabetes mellitus (OR = 1.06, OR = 1.12, OR = 1.06 and OR = 1.19), hyperlipidemia (OR = 1.44, OR = 1.49, OR = 1.45, and OR = 1.19), coronary heart disease (OR = 1.06, OR = 1.11, OR = 1.10, and OR = 1.22), atrial fibrillation (OR = 1.57, OR = 1.59, OR = 1.57, and OR = 1.32) and dementia (OR = 1.96, OR = 1.75, OR = 2.02, and OR = 6.08). Obesity was related to stroke only in 2007 (OR = 1.73) and 2010 (OR = 1.43). The cost for stroke in 2007 was $44,327 for the first stroke discharge, which increased to $62,709, $69,512 and $73,878 in 2008, 2009, and 2010, while the total annual cost for stroke patients increased from $141,290 in 2007 to $178,030 in 2008, to $195,420 in 2009, and it decreased to $130,860 in 2010. The cost in all years was higher for males than females, higher for Asian/Pacific islanders (AP) in 2007, 2009, and 2010, and higher for Blacks in 2008.

Conclusions: Conclusions include: (1) stroke prevalence among hospitalized patients and the number of stroke admissions per year declined in California during 2007-2010; (2) decline in Hospital costs in 2010 was associated with shorter length of hospitalization from 23 days in 2007 to 16 days in 2010; (3) Seven traditional risk factors were consistently associated with stroke across all four years.

Keywords: Stroke Risk Factors; Stroke Prevalence; Race; Ethnicity; Sex; Hospital Costs

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Introduction

More than 795,000 adults experience strokes each year and nearly 88% of strokes are classified as Ischemic strokes (IS) which affect both males and females, with an estimated healthcare cost of $34 billion per year. Stroke prevalence varies according to age and sex, and in general, stroke prevalence is higher among older individuals, among females, and those from certain minority groups [1-11].

Risk factors

Previous studies such as the Northern Manhattan Study (NOMAS) [1] and the Framingham Heart Study (FHS) [2] have pointed to various risk factors associated with stroke that include hypertension (HTN) [11-13], diabetes mellitus (DM) [11,14], hyperlipidemia (HDL) [15], atrial fibrillation (Afib) [11,16], chronic kidney disease (CKD) [17-19], sleep apnea [20], dementia [11,21,22] and depression[23,24]. While we examine these traditional risk factors, what remains unknown is the variation in risk factors by race, ethnicity and sex, and hospital costs of elderly (aged 65 + ) stroke patients. Thus in this examination of California stroke patients, we examine three stroke related issues by race, ethnicity and sex: (1) variations in stroke prevalence over four years; (2) variations in stroke risk factors; and (3) variations in Hospital Costs of Stroke patients over four years (2007 - 2010).

Sample characteristics

We obtained 2007 - 2010 Hospital Discharge Data (HDDS) from the California Office of Statewide Health Planning and Development (OSHPD) on patients aged 65+ years. From this cohort, we selected patients with a primary diagnosis of stroke (ICD9 codes 430 - 438, mean age 80, females 56%; stroke sample included in 2007 (n = 13,027); in 2008 (n = 12,676); in 2009 (n = 11,521); and in 2010 (n = 7845) along with their demographics (age, sex), comorbidities, number of admissions, length of stay (days), and charges (cost USD $) for each discharge.

For each patient, two indices of co-morbidities were computed: (i) a simple count of all secondary diagnoses (co-morbidities) that were identified by ICD-9-CM codes; and (ii) Charlson Index [25] of severity of co-morbidity. Further, two measures of cost were developed: (1) cost for 1st stroke discharge, and (2) total cost for the same patient that included the cost for 1st stroke discharge plus the cost for other discharges with different diagnoses during the year.

Statistical analysis: Differences between Stroke and Non-Stroke patients as well as the prevalence of stroke and risk factors by race, ethnicity, and sex, were all evaluated with logistic regression models, Pearson X$^2$ and the Fisher's Exact Tests. Cost differences between groups were evaluated with ANOVA.

Results

Stroke Prevalence

Stroke prevalence seemingly declined over the study period from 6.3% to 4.5%. As supported by previous studies, the prevalence was higher among females and blacks compared to other groups [4,5]. Moreover, Table 1 shows a decline in stroke admission from 13,027 admissions in 2007 to 7,845 stroke admissions in 2010 (a decline of 40% over four years). Similar decline was noted in Stroke rate per 100,000 population which declined from 235 per 100,000 population in 2007 to 201 in 2010.

Risk factors related to stroke

While 7 of 12 risk factors (HTN, DM, HDL, CHD, Afib, Depression, and Dementia), were consistently associated with strokes in each of 2007, 2008, 2009, and 2010 (See Table 1), obesity was associated with stroke only in 2007 and 2010. Further, there was little variation in stroke risk factors by race, ethnicity or sex as shown in Table 1 below. Chronic kidney disease was not related to stroke in a statistically significant manner.
## Changes in Risk Factors and Hospital Cost of Stroke Care Among California Elderly Over Four Years, 2007-2010

### Table 1: Stroke and Risk Factors Among California Elderly Patients Over 2007 – 2010.

Significant Odds Ratios ($p < .001$) of Factors Associated with Stroke By Ethnicity And Sex, 2007 - 2010.

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>HTN, DM, HDL, CHD, AFIB, DEP, DEMENT</td>
<td>HTN, DM, HDL, CHD, AFIB, DEP, DEMENT</td>
<td>HTN, DM, HDL, CHD, AFIB, DEP, DEMENT</td>
<td>HTN, DM, HDL, CHD, AFIB, DEMENT</td>
</tr>
<tr>
<td>Black</td>
<td>HTN, HDL, AFIB, DEP, DEMENT</td>
<td>HTN, HDL, AFIB, DEP, DEMENT</td>
<td>HTN, HDL, AFIB, DEP, DEMENT</td>
<td>HTN, HDL, AFIB, OBES, DEMENTIA</td>
</tr>
<tr>
<td>Hispanic</td>
<td>HTN, DM, HDL, AFIB, OBES, DEP, DEMENT</td>
<td>HTN, DM, HDL, AFIB, DEP, DEMENT</td>
<td>HTN, HDL, CHD, OBES, DEP, DEMENT</td>
<td>HTN, HDL, CHD, AFIB, OBES, DEMENTIA</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>HTN, HDL, AFIB, OBES, DEP, DEMENT</td>
<td>HTN, HDL, CHD, AFIB, OBES, DEP, DEMENT</td>
<td>HTN, HDL, AFIB, DEP, DEMENT</td>
<td>HTN, HDL, AFIB, DEP, DEMENTIA</td>
</tr>
</tbody>
</table>

### Table 2: Changes in Risk Factors and Hospital Cost of Stroke Care Among California Elderly Over Four Years, 2007-2010.

<table>
<thead>
<tr>
<th>Year</th>
<th>N</th>
<th>Mean age</th>
<th>Female %</th>
<th>Stroke %</th>
<th>Rate/100</th>
<th>DEP %</th>
<th>HTN %</th>
<th>DM %</th>
<th>HDL %</th>
<th>CHD %</th>
<th>HF %</th>
<th>MI %</th>
<th>AFIB %</th>
<th>CKD %</th>
<th>COPD %</th>
<th>Obese %</th>
<th>Dement %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>13027</td>
<td>80.6</td>
<td>56.6</td>
<td>6.3</td>
<td>235</td>
<td>1.10*</td>
<td>2.30*</td>
<td>1.06+</td>
<td>1.44*</td>
<td>1.06+</td>
<td>.50</td>
<td>.79</td>
<td>1.57*</td>
<td>.87</td>
<td>.80</td>
<td>1.73*</td>
<td>1.96*</td>
</tr>
<tr>
<td>2008</td>
<td>12676</td>
<td>80.3</td>
<td>57.0</td>
<td>6.3</td>
<td>218</td>
<td>1.10*</td>
<td>2.32*</td>
<td>1.12*</td>
<td>1.49*</td>
<td>1.11*</td>
<td>.49</td>
<td>.74</td>
<td>1.50 - 1.65</td>
<td>.91</td>
<td>.75</td>
<td>1.28 - 2.33</td>
<td>1.79 - 2.14</td>
</tr>
<tr>
<td>2009</td>
<td>11521</td>
<td>80.9</td>
<td>57.2</td>
<td>6.2</td>
<td>200</td>
<td>1.10*</td>
<td>2.22*</td>
<td>1.06</td>
<td>1.45*</td>
<td>1.10*</td>
<td>.46</td>
<td>.68 - .80</td>
<td>.87</td>
<td>.71</td>
<td>1.15 - 1.68</td>
<td>1.59 - 1.92</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>7845</td>
<td>81.2</td>
<td>55.1</td>
<td>4.5</td>
<td>201</td>
<td>1.18*</td>
<td>1.51*</td>
<td>1.06</td>
<td>1.19*</td>
<td>1.18 - 1.25</td>
<td>.51</td>
<td>.78</td>
<td>1.51 - 1.67</td>
<td>.88</td>
<td>.83</td>
<td>1.10 - 1.60</td>
<td>2.02 - 2.28</td>
</tr>
</tbody>
</table>

**Citation:** Baqar Husaini., *et al.* "Changes in Risk Factors and Hospital Cost of Stroke Care Among California Elderly Over Four Years, 2007-2010." *EC Neurology* 11.8 (2019): 630-639.
Stroke hospital costs

**Three notable results emerged from the hospital cost analyses:** (1) Total stroke costs for the year declined by 7% from $141,290 in 2007 to $130,860 in 2010 (Table 2). The higher costs during 2007-2009 were largely due to longer hospitalization (23.2 days in 2007, 21.9 days in 2008, 21.2 in 2009) compared to fewer days in 2010 (16.0 days); (2) Hospital costs varied by race and sex in that cost for Asian Pacific Islanders (AP) were significantly higher (p < .01) each year compared to other racial and ethnic groups. Similarly, the costs for male stroke patients were higher each year compared to females (See bottom of Table 2); and (3) More than 50% of the total hospital costs in 2010 were from the cost of 1st stroke hospitalization ($73,878 of $130,860).

<table>
<thead>
<tr>
<th>Cost Factors</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Col→</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>#Comorb</td>
<td>4.2</td>
<td>4.44</td>
<td>4.3</td>
<td>4.6*</td>
</tr>
<tr>
<td>Charlson</td>
<td>3.2</td>
<td>4.1</td>
<td>3.5</td>
<td>4.3*</td>
</tr>
<tr>
<td># Adm</td>
<td>2.1</td>
<td>2.7</td>
<td>2.1</td>
<td>2.7*</td>
</tr>
<tr>
<td>LOS</td>
<td>15.7</td>
<td>23.2</td>
<td>16.3</td>
<td>21.9*</td>
</tr>
<tr>
<td>1st Stroke $</td>
<td>-----</td>
<td>44,357</td>
<td>------</td>
<td>62,709</td>
</tr>
<tr>
<td>Total Cost $</td>
<td>124,450</td>
<td>141,290</td>
<td>156,840</td>
<td>178,010</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ethnic Grp</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>141,290</td>
<td>178,010</td>
<td>195,420</td>
<td>130,860</td>
</tr>
<tr>
<td>White</td>
<td>128,350</td>
<td>162,410</td>
<td>178,990</td>
<td>120,180</td>
</tr>
<tr>
<td>Black</td>
<td>164,140</td>
<td>226,050*</td>
<td>226,620</td>
<td>130,700</td>
</tr>
<tr>
<td>Hispanic</td>
<td>157,040</td>
<td>192,800</td>
<td>213,800</td>
<td>145,390</td>
</tr>
<tr>
<td>AP</td>
<td>190,060*</td>
<td>218,690</td>
<td>256,430*</td>
<td>187,500*</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>147,580*</td>
<td>188,080*</td>
<td>209,880*</td>
<td>137,060*</td>
</tr>
<tr>
<td>Female</td>
<td>136,460</td>
<td>170,620</td>
<td>184,860</td>
<td>125,820</td>
</tr>
</tbody>
</table>

**Table 2:** Hospital Cost Factors of California Elderly Stroke Patients, 2007-2010.

Hospital Cost by Race/Ethnicity And Sex, 2007-2010.

*Differences Are Significant at P < .001 # Comorb= Number of Comorbidities; Charlson: Charlson Index of Comorbidity Severity; # Adm: Number of Hospital Admissions; LOS: Length of Hospital Stay; 1st Stroke $: Cost For 1st Stroke Admission; Total Cost $: Total Stroke Cost for The Year.

**Discussion**

Our findings are relevant from multiple perspectives: First, we found that the stroke prevalence declined from 6.3% in 2007 to 4.5% in 2010, which is consistent with the previously seen nationwide pattern of decreasing stroke rates from 1988 on [26,27]. The greater occurrence of stroke amongst blacks and women is consistent with other large observational studies [27-31].

Several hypotheses may be generated by these data. We found that obesity was only a significant risk factor for strokes in our patient population as a whole in 2007 and 2010. While obesity is a known risk factor for stroke independent of race and sex [28-31], we saw...
that obesity was a risk factor for Hispanics in 2007, 2009, and 2010, among AP in 2007 and 2008, and among blacks in 2010. This may be related to disparities in access to health care and preventive health campaigns [32-35]. Alternatively, since most stroke deaths occur prior to hospitalization [36], variations in these and other results in the present data could reflect changes in pre-hospital circumstances over time.

The decline in stroke prevalence in patients discharged from California hospitals from 2007-2010 may also be related to cumulative effects of better recognition of stroke and preventive measures including blood pressure control [37-40], increasing use of cholesterol controlling pharmaceuticals (statins) [41-45], treating AFib before stroke onset [46], a greater focus on exercise, fitness, and other nonpharmaceutical factors [47,48]. Using data from the National Health Survey, Gu and Colleagues [42] reported that statin prescriptions among people aged 40 and over increased from 18.9% to 23.2% from 2007 - 2011. Since the effects of statins on reducing the risk of CVD, including stroke, has been reported in several studies [43-45], it is plausible that the change in our sample (stroke prevalence declined from 6.5% to 4.5%), is may, in part, be due to the increased use of statins. Since data on statin use among our patients is not available, this issue requires further examination.

While most risk factors for stroke were consistent between 2007 and 2010, odds ratios of HTN, HDL, and Afib decreased, while the odds ratios for DM, CHD, and Dementia increased. The increase in odds ratio of dementia, from 1.96 to 6.08, may be partially explained by a change in the definition and diagnosis of Alzheimer’s Disease. The International Working Group introduced the framework for new criteria for Alzheimer’s Disease in 2007, with a position paper in 2010 [49-51]. Combined with increases in the rate of dementia diagnosis [52], this large increase in odds ratio may reflect, in part a shift in how dementia was recognized more than an increase in dementia in stroke patients. In our analysis, dementia included all sub-types and Alzheimer (AD). There was no need to separate Alzheimer as a separate category since its effect were reported separately [70].

We also found that the cost for the first stroke discharge increased from $44,357 in 2007 to $73,878 in 2010. At the same time, the Total annual Cost initially increased from $141,290 in 2007 to $195,420 in 2009 before falling to $130,860 in 2010 (Table 2). The length of stay (LOS) also decreased from 23.2 days in 2007 to 16.0 days in 2010. Several potential explanations for these changes are offered including that Food and Drug Administration (FDA) approved in 2010 the use of Dabigatran for the prevention of stroke in patients with Afib [53,54], which reduced costs for patients (aged 65 + years old) with prescription drug coverage. Another change in management that may have had an effect on the cost and length of stay (LOS) was the impact of the 2010 American Heart Association (AHA) guideline update [55-57] emphasizing the time sensitive nature of stroke recovery. Further, other factors that may also contribute to lower cost include Get With the Guidelines program [55-57], an AHA nationwide stroke initiative, better systems of stroke care evolved with emphasis on early recognition [57,58], early treatment with intravenous thrombolitics [54-59], or mechanical thrombectomy [60,61], stress on initiating high dose statins at stroke onset [62-65]and addressing underlying etiologies as soon as possible such as an anticoagulation for patients with atrial fibrillation [66-69]. Finally, combined with an emphasis on overhauling the systems behind hospital stroke treatment [69], these administrative changes could be a reason for the change in both cost and length of stay (LOS) for stroke patients. The decrease in LOS is itself a major cause of the reduction in cost. It is well established that a longer LOS is associated with higher costs [66-69] and that lowering the time spent in the hospital directly decreases patient expenses [69].

Data Limitations

The HDDS files do not provide patient clinical data regarding the treatment type or out of hospital treatments, including pharmaceuticals and associated costs. These administrative files further do not contain the marital status, educational level, or annual income of the patients. Moreover, hospital discharge data do not provide information on pre-hospital stroke mortality. Despite these limitations, the current
findings are relevant both as a guide for developing analytic epidemiologic studies to test hypotheses generated by these descriptive data.

Conclusions

Several conclusions can be drawn from these findings: (1) both stroke prevalence per 100,000 population and the number of stroke discharges per year declined from 2007 to 2010 in California; (2) the observed decline in hospital costs in 2010 was associated with shorter length of hospitalization; and (3) the consistent association of traditional risk factors across all four years by race, ethnic and sex groupings may reflect the abiding importance of these factors and the importance of healthcare awareness and/or specific intervention strategies. The results however do warrant population-based epidemiologic research to confirm or deny the many hypotheses generated by these data. Such studies should include both pre- and post-hospital occurrences of stroke.

Acknowledgement

Bibliography


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