Reduced Medication Access
A Marker for Vulnerability in US Stroke Survivors
Deborah A. Levine, MD, MPH; Catarina I. Kiefe, PhD, MD; George Howard, DrPH; Virginia J. Howard, MSPH; O. Dale Williams, PhD; Jeroan J. Allison, MD, MSc

Background and Purpose—Medication access is crucial to secondary stroke prevention. We assessed medication access and associated barriers to care across region and time in a national sample of US stroke survivors.

Methods—Among all 5840 black or white stroke survivors aged ≥45 years responding to the National Health Interview Survey years 1997 to 2004, we examined inability to afford medications within the last 12 months across region (Northeast, Midwest, West, South) and time. With logistic regression, we adjusted associations between medication inaffordability and region and time for age, sex, race, neurological disability, comorbidity, health status, insurance, income and out-of-pocket medical expenses.

Results—In 2004, ≈76 000 US stroke survivors were unable to afford medications. Lower medication affordability was reported among stroke survivors who were <65 years old, black, female, had high comorbidity or low health status. Compared with stroke survivors able to afford medications, those unable more frequently reported lack of transportation (15% versus 3%; P<0.001), no health insurance (16% versus 3%; P<0.001), no usual place of care (6% versus 2%; P=0.001), income <$20 000 (66% versus 40%; P<0.001) and out-of-pocket medical expenses ≥$2000 (35% versus 25%; P<0.001). From 1997 to 2004, inability to afford medications increased significantly from 8.1% to 12.7% (Ptrend=0.01) overall and increased in all US regions except the Northeast.

Conclusions—We identified a vulnerable stroke survivor population with reduced medication access and increased barriers to medical care. Membership in this population has grown substantially from 1997 to 2004, potentially leading to increased recurrent stroke incidence. (Stroke. 2007;38:1557-1564.)

Key Words: access to health care ■ secondary prevention ■ stroke

In 2003, ≈5.5 million US stroke survivors required secondary prevention including risk factor modification.1 Ischemic stroke survivors have a 4% to 14% annual risk of recurrent stroke1−3 and experience cardiovascular events that increase their morbidity, mortality, and healthcare costs.2 Secondary stroke prevention often requires pharmacological therapy to modify risk factors such as hypertension and diabetes mellitus. Despite evidence-based clinical practice guidelines for secondary stroke prevention, risk-factor modification among US ischemic stroke survivors remains inadequate.4−9

Medication access among stroke survivors may be an important barrier to secondary stroke prevention. Reduced medication access may be associated with other barriers to care. Recent changes in the US economy, higher uninsured rates,10,11 lack of prescription coverage,12 rising prescription drug prices,13 and increased out-of-pocket medical spending14 and prescription drug cost-sharing15 may cause decreased medication affordability. In the US, Southern stroke survivors may have reduced medication access because residents of the South have lower median household income16 and are more frequently uninsured.11,16,17 Regional differences and temporal trends in medication access for the US national population of stroke survivors have not been examined.

This study assesses regional differences and recent temporal changes in medication access, as well as patient characteristics and other barriers to care associated with lack of medication access among community-dwelling stroke survivors using data from a nationally representative, population-based survey.

Methods

Study Population
The National Health Interview Survey (NHIS) is a continuing, in-person household survey of the civilian, noninstitutionalized US population conducted annually by the National Center for Health

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Statistics (NCHS) using face-to-face interview.\textsuperscript{18} Data from NHIS survey years 1997 to 2004, which use similar survey designs and data collection methods,\textsuperscript{18} were combined for this report. The final response rates for the sample adult survey years 1997 to 2004 ranged from 70\% to 80\%.\textsuperscript{18} Specific information regarding the NHIS survey is available elsewhere.\textsuperscript{18}

Stroke survivors were identified as respondents who answered yes to the question “Have you ever been told by a doctor or other health professional that you had a stroke?” Place of residence was identified by geographic region. The US Census Bureau groups the 50 states and the District of Columbia for statistical purposes into 4 geographic regions—Northeast (Maine, Vt, N.H., Mass, Conn, R.I., N.Y., N.J., Pa), Midwest (Ohio, Ill, Ind, Mich, Wis, Minn, Iowa, Mo, N.D., S.D., Kans, Nebr), South (Del, Md, District of Columbia, W.Va., Va, Ky, Tenn, N.C., S.C., Ga, Fla, Ala, Miss, La, Okla, Ark, Tex) and West (Wash, Ore, Calif, Nev, N.M., Ariz, Idaho, Utah, Colo, Mont, Wyo, Alaska, Hawaii).\textsuperscript{18} The 1995 to 2004 NHIS was designed to produce population-based estimates for the entire US and for each of the 4 census regions.\textsuperscript{19} Although the 1995 to 2004 survey samples from all US states and the District of Columbia, it was not designed to produce reliable state-level estimates.\textsuperscript{19} To ensure reliable estimates for black persons, the 1995 to 2004 NHIS over-samples black persons at an approximate rate of 1.5:1.\textsuperscript{19}

**Outcome Measure**

Report of an inability to afford medications (“During the past 12 months, was there any time when you needed prescription medicines, but didn’t get [them] because you couldn’t afford [them]?”) was the outcome measure.

**Statistical Analysis**

The frequency of the outcome measure across the individual survey years (1997 to 2004) in the overall cohort and within region was compared using \( \chi^2 \) test for trend. Healthcare access variables and the outcome measure were compared using \( \chi^2 \) test and US population-based estimates were calculated. Covariates were selected based on the Behavioral Model for Vulnerable Populations framework,\textsuperscript{20,21} literature review and clinical observation. Covariates included age (45 to 64 versus \( \geq \)65 years), race-sex (white male, white female, black male, black female), education, region (Northeast, Midwest, South, West), annual household income, out-of-pocket medical expenses (including dental care but excluding costs related to health insurance premium fees, over the counter remedies or reimbursable expenses), place of residence, and out-of-pocket medical expenses. The point estimates and 95\% CIs for the covariates did not change significantly in the incremental logistic regression models so the final model is presented. The final model, Model B, included the same covariates in Model A plus the 3 health access variables. Three covariates, usual place of care, education and lack of transportation, were excluded because of lack of statistical contribution to the multivariable models. All analyses used SAS-callable SUDAAN software, version 9.0.1 (Research Triangle Inst) to obtain proper variance estimations that accounted for the complex sampling design of NHIS and results that were weighted to reflect national population estimates. Appropriate institutional review board approval was obtained from the University of Alabama at Birmingham.

**Results**

We identified 5840 stroke survivors aged \( \geq \)45 years, representing an estimated 4.1 million US stroke survivors, of whom 1.6 million (40\%) reside in the South. During the period from 1997 to 2004, 9\% of stroke survivors nationwide, \( \approx \)378 000 persons, reported an inability to afford medications. Stroke survivors with medication inaffordability had higher proportions of persons aged 45 to 64 years (56\%), in the South (49\%), with less than high school education (45\%), black race (20\%), and female sex (60\%) compared with stroke survivors with medication affordability (Table 1). Stroke survivors with medication inaffordability were as likely as those with affordability to report neurological disability attributable to stroke but more likely to report low health status and \( \geq \)2 comorbidities, including higher rates of hypertension, diabetes and coronary heart disease, than stroke survivors with medication affordability.

**Inability to Afford Medications and Associated Barriers to Care Among US Stroke Survivors**

Compared with stroke survivors able to afford medications, those who were unable had higher frequencies for other barriers to care, including lack of transportation delaying care (15\% versus 3\%; \( P<0.001 \)), no health insurance (87\% versus 3\%; \( P<0.001 \)), no usual place of care (61\% versus 2\%; \( P=0.001 \)), household income <\$20 000 (66\% versus 40\%; \( P<0.001 \)) and out-of-pocket medical expenses <\$2000 (35\% versus 25\%; \( P<0.001 \); Table 1). Medication inaffordability varied significantly by health insurance type, with the highest rates (37\%) among stroke survivors without health insurance; modest but similar rates (12\% to 14\%) among survivors with Medicaid and Medicare, Medicare only, or Other insurance; and lowest rates (5\%) among stroke survivors with Private with or without Medicare insurance (\( P<0.001 \); Figure 1).

**Regional Differences in Inability to Afford Medications Among US Stroke Survivors**

Stroke survivors in the South had higher proportions of persons aged 45 to 64 years (35\%), with less than high school education (41\%) and annual household income <\$20 000 (46\%). The South had more black stroke survivors (19\%) than did other regions. For the 1997 to 2004 period overall, inability to afford medications among stroke survivors was similar in the South (weighted percentage 11\%; population estimate 184 173), West (10\%; 67 872) and Midwest (9\%; 88 369) regions but lower in the Northeast (5\%; 37 361; Figure 2).

Regional differences in other barriers to care were found. Household income <\$20 000 (South 46\%, Midwest 44\%, West 40\%, Northeast 36\%; \( P<0.001 \)) and out-of-pocket medical expenses <\$2000 (South 29\%, Midwest 26\%, West 25\%, Northeast 19\%; \( P<0.001 \)) were less frequently reported.
by stroke survivors in the Northeast. Although uninsured rates were similar across regions (≤5%), stroke survivors in the South and West had lower rates of Private with or without Medicare insurance (Midwest 68%, Northeast 66%, South 51%, West 49%), the insurance type associated with higher medication affordability.

**Temporal Trends in Inability to Afford Medications Among US Stroke Survivors**

The proportion of stroke survivors unable to afford medications increased from 8.1% in 1997 to 12.7% in 2004 (P_trend = 0.01; Figure 3) representing a doubling in the population estimate from 37 111 to 75 630. From 1997 to 2004,
medication inaffordability for stroke survivors increased in all regions except the Northeast (Figure 4). The percentage of stroke survivors reporting an inability to afford medications from 1997–1998 to 2003–2004 changed as follows: Northeast 5.7% to 4.9% (Ptrend/H11005 0.97), Midwest 6.4% to 10.5% (Ptrend/H11005 0.32), South 9.8% to 15.1% (Ptrend/H11005 =0.03) and West 6.8% to 15.0% (Ptrend/H11005 =0.12); overall Ptrend/H11005 0.004. Some regional subgroups had small sample size. During the study period, other barriers to care also changed over time. Specifically, from 1997 to 2004, income $20 000 decreased (50% to 42%; P 0.001), out-of-pocket medical expenses $2000 increased (21% to 27%; P 0.001), and lack of health insurance remained stable (5% to 4%; P=0.76).

Effect of Adjustment for Demographic and Clinical Characteristics

In unadjusted analyses, region and survey period were associated with inability to afford medications. Lower odds of the outcome were seen in the Northeast (odds ratio [OR], 0.41; 95% CI, 0.29 to 0.59) and Midwest (OR, 0.76; 95% CI, 0.59 to 0.98; R2 for dependent variable,22 0.002) regions compared with the South region (referent). Higher odds of the outcome were seen in the 2001 to 2004 period (OR, 1.41; 95% CI, 1.15 to 1.73; R2 for dependent variable, 0.002) compared with the 1997 to 2000 period. After adjustment, Midwest and West regions had similar odds of inability to afford medications, and the Northeast region appeared to have lower odds of inability to afford medications compared with the Southern region. More recent survey period (OR, 1.42; 95% CI, 0.28 to 0.61) remained inversely associated with inability to afford medications (Model A, Table 2).

Effect of Adjustment for Healthcare Access Variables

The regional and temporal differences persisted (Model B, Table 2) after further adjustment for health insurance, household income and out-of-pocket medical expenses. Compared with white men, white women and black women had significantly lower odds of medication affordability. Factors independently associated with inability to afford medications included age, comorbidity, self-reported health status, health insurance, and household income. The adjusted odds of inability to afford medications increased as out-of-pocket medical expenses increased (Model B, Table 2). The small
number of stroke survivors in the Northeast reporting medication inaffordability precluded an examination of regional interactions in detail.

Because of significantly lower rates of the outcome found among stroke survivors in the Northeast, all analyses were repeated in the subsample of stroke survivors living outside the Northeast. In unadjusted analyses, inability to afford medications varied by region ($P=0.10$) with lower odds seen in the Midwest (OR, 0.76; 95% CI, 0.59 to 0.98) but similar odds in the West (OR, 0.87; 95% CI, 0.66 to 1.16) compared with the South (referent). In adjusted analyses, the results did not differ from the results presented in Table 2.

**Discussion**

In this nationally representative sample, we identified a vulnerable stroke survivor population, defined by reporting inability to afford medications, and with additional barriers to care, and equal or greater need for medical care. Based on our data, we estimate that 76 000 US stroke survivors in 2004 did not fill a medication prescription because they could not afford to do so. Stroke survivors unable to afford medications also had increased frequency of lack of transportation that delayed care, no health insurance, no usual place of care, income <$20 000, and higher out-of-pocket medical expenses. Stroke survivors with reduced medication access had greater need for care with higher prevalence rates of major comorbidities, such as coronary artery disease and chronic kidney disease, and stroke risk factors, such as diabetes and hypertension.

During the study period (1997 to 2004), the percentage of stroke survivors reporting an inability to afford medications increased from 8% in 1997 to 13% (57% increase) in 2004 ($P_{trend}=0.01$). According to data from the Community Tracking Study Household Survey, a similar trend was also seen in US adults with chronic conditions from 2001 to 2003 and attributed to higher prescribing rates, higher prescription drug needs and increased patient cost-sharing. Among adults with chronic conditions surveyed in 2003, inability to afford...
medications was greater among uninsured, black and low-income persons. Similarly, we found increased difficulty affording medications among uninsured, black, poor as well as female, nonelderly and ill adult US stroke survivors. In 2005, 59% of uninsured adults (age 19 to 64 years) with at least 1 chronic condition (including stroke) skipped medication doses or did not fill a medication prescription for a chronic condition because of cost.

Our data demonstrate that medication inaffordability both increases as out-of-pocket medical expenses rise and varies significantly by health insurance type, with lowest rates for stroke survivors with Private with or without Medicare insurance (5%) and highest rates for uninsured stroke survivors (37%). Higher out-of-pocket spending on medications is seen with increasing number of chronic conditions and, in patients with diabetes, has been associated with higher rates of cost-related medication underuse and decreased spending on basic needs such as food or heat. Moreover, cost-related medication underuse has been shown to vary by health insurance type. In 2 separate surveys of diabetic patients and patients with chronic illnesses, cost-related medication underuse was lowest among Veterans Affairs patients (9% and 12% respectively) and highest among patients with no health insurance (40% and 35% respectively).

From 1997 to 2004, medication affordability worsened for stroke survivors in the South, Midwest and West regions but appeared to remain stable in the Northeast, although the sample size on which to base the latter conclusion is quite limited. Importantly, a disproportionate number of stroke survivors with reduced medication access, ≈184 000 persons, and no health insurance, nearly 80 000 persons, resided in the Southern US. The etiology of greater difficulty affording medications among stroke survivors outside the Northeast, after adjusting for health insurance, income and out-of-pocket medical expenses, is uncertain. Explanations for the regional differences in medication affordability may include unmeasured differences in supplemental insurance, prescription drug coverage, public assistance rates, and competing household costs, none of which could be assessed directly in our analysis.

Recent data suggest that inability to afford medications may have a major impact on stroke survivors’ medication use. Using survey data assessing patient decision-making related to medication adherence, Piette and colleagues estimated a 22% probability of stroke preventive medication underuse attributable to cost for the average American adult aged ≥50 years with average out-of-pocket medication costs and no prescription coverage, a probability that would increase to 49% if the adult had a prior instance of cost-related medication underuse in the previous year. Nonadherence, specifically for antihypertensive and diabetic medications, has been associated with lack of prescription coverage, and increased prescription copayments. Increased serious adverse events and emergency department visits, and, among adults with pre-existing cardiovascular disease, higher rates of angina and nonfatal stroke or myocardial infarction.

Stroke survivors require medication access in order to adequately modify risk factors, eg, hypertension and diabetes reported by 72% and 26% of stroke survivors in our cohort respectively, that predispose to recurrent stroke and other cardiovascular events. Younger stroke survivors (age 45 to 64 years) have reduced access to health insurance and medications compared with older stroke survivors (age ≥65 years). The CARES study found that stroke survivors were discharged home from rehabilitation with an average of 11.3 medications (range 3 to 27). Using the monthly Average Wholesale Price (2004), the total monthly cost of the 10 medications was greater among uninsured, black and low-income persons. Similarly, we found increased difficulty affording medications among uninsured, black, poor as well as female, nonelderly and ill adult US stroke survivors. In 2005, 59% of uninsured adults (age 19 to 64 years) with at least 1 chronic condition (including stroke) skipped medication doses or did not fill a medication prescription for a chronic condition because of cost.

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### TABLE 2. Adjusted ORs (95% CIs) for Inability to Afford Medications Among Stroke Survivors, Before and After Adjusting for Selected Healthcare Access Variables: National Health Interview Survey, 1997–2004†‡

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR (95% CI) for Inability to Afford Medications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model A†</td>
</tr>
<tr>
<td>Survey period 2001–2004 (vs 1997–2000)</td>
<td>1.42 (1.14, 1.77)</td>
</tr>
<tr>
<td>Age 45–64 years (vs ≥65 years)</td>
<td>3.04 (2.44, 3.78)</td>
</tr>
<tr>
<td>Race-sex</td>
<td></td>
</tr>
<tr>
<td>White male</td>
<td>1.00</td>
</tr>
<tr>
<td>White female</td>
<td>1.79 (1.39, 2.32)</td>
</tr>
<tr>
<td>Black male</td>
<td>1.59 (1.04, 2.42)</td>
</tr>
<tr>
<td>Black female</td>
<td>1.81 (1.26, 2.58)</td>
</tr>
<tr>
<td>Region</td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>0.41 (0.28, 0.61)</td>
</tr>
<tr>
<td>Midwest</td>
<td>0.86 (0.65, 1.12)</td>
</tr>
<tr>
<td>South</td>
<td>1.00</td>
</tr>
<tr>
<td>West</td>
<td>0.97 (0.71, 1.32)</td>
</tr>
<tr>
<td>Neurological disability attributable to stroke</td>
<td>0.85 (0.68, 1.07)</td>
</tr>
<tr>
<td>≥2 Comorbidities</td>
<td>1.75 (1.37, 2.23)</td>
</tr>
<tr>
<td>Low self-reported health status</td>
<td>2.17 (1.66, 2.84)</td>
</tr>
<tr>
<td>Health insurance status</td>
<td></td>
</tr>
<tr>
<td>Private with or without Medicare</td>
<td>0.16 (0.10, 0.26)</td>
</tr>
<tr>
<td>Medicaid and Medicare</td>
<td>0.28 (0.16, 0.48)</td>
</tr>
<tr>
<td>Medicare only</td>
<td>0.41 (0.25, 0.66)</td>
</tr>
<tr>
<td>Other</td>
<td>0.21 (0.12, 0.37)</td>
</tr>
<tr>
<td>Uninsured</td>
<td>1.00</td>
</tr>
<tr>
<td>Income &lt;$20 000</td>
<td>2.66 (2.00, 3.55)</td>
</tr>
<tr>
<td>Out-of-pocket medical care expenses</td>
<td></td>
</tr>
<tr>
<td>&lt;$500</td>
<td>1.00</td>
</tr>
<tr>
<td>$500–$1999</td>
<td>1.66 (1.23, 2.24)</td>
</tr>
<tr>
<td>≥$2000</td>
<td>2.40 (1.72, 3.35)</td>
</tr>
</tbody>
</table>

*Data Source: National Center for Health Statistics (1997–2004).†Each column represents one model. Model A adjusts for region, age, neurological disability attributable to stroke, race-sex, ≥2 comorbidities, self-reported health status and survey period. Model B adjusts for the same factors in Model A plus health insurance status, household income and out-of-pocket medical expenses. Bold figures indicate 95% CIs not containing one.‡‡R² for dependent variable: Model A (0.065), Model B (0.117).
common prescription medications for stroke survivors was \( \approx \$725 \). Given improved stroke survival, \(^{37-39}\) constant age-specific stroke incidence, \(^{37,38,40}\) increasing size of the 65 and older population, \(^{41}\) and increasing number of uninsured non-elderly in the US, \(^{10}\) the chronic care of stroke survivors will prove costly.

Health insurance for uninsured stroke patients would be expected to reduce out-of-pocket medical spending \(^{14}\) and, from the data presented here, to improve medication affordability. Affordable health insurance options would be required for all stroke survivors including 2 particular subgroups of uninsured stroke survivors: working stroke survivors unable to afford employer-based health insurance \(^{42}\) and disabled stroke survivors aged <65 years because they do not qualify for Medicare health insurance unless receiving Social Security or Railroad Retirement Board disability benefits for \( \geq 2 \) years. \(^{43}\) For the insured, affordable prescription coverage with reasonable out-of-pocket copayments would be required to increase medication affordability and decrease cost-related medication underuse. \(^{12,23,31,44}\)

Our study has several limitations. Given the observational study design, we cannot infer causation from the associations that we found. Unadjusted risk between groups and persistent confounding may exist. Several factors including provider characteristics, stroke type, stroke severity, and stroke acuity could not be assessed adequately. The NHIS lacks additional questions regarding medication affordability such as which prescription medications are not obtained. Although state-level variation and type of geographic area could not be evaluated, rural residents have lower incomes, lower rates of insurance coverage and greater financial barriers to care than urban residents. \(^{45}\) These NHIS data are self-reported and subject to recall bias and reporting error. Although respondents may inaccurately report a history of stroke, \(^{46,47}\) more recent reports suggest higher self-reported stroke accuracy, \(^{48}\) even in the disabled elderly. \(^{49}\) Given the NHIS sampling design, this analysis includes community-dwelling, noninstitutionalized stroke survivors. Selection bias may occur if stroke survivors with reduced medication access are less frequently sampled compared with stroke survivors with adequate medication access. However, expected population-based estimates approximate our calculated number of stroke survivors.

Summary

Our findings demonstrate a recent temporal decline in medication access for US stroke survivors, an essential component of secondary stroke prevention. Further, from 1997 to 2004, medication access for stroke survivors worsened for all US regions except the Northeast. Clinicians caring for stroke survivors need to ascertain and incorporate medication affordability into their medical decision-making regarding risk factor modification interventions. Additional research is needed to understand the temporal and regional differences in medication access including further analyses of the influence of insurance type and benefits, and to determine whether stroke survivors with less medication access have increased adverse clinical outcomes or healthcare utilization. Work to reduce healthcare access problems and to identify effective and cost-effective quality improvement programs is required.

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Disclosures

All analyses, interpretations, and conclusions reached are attributed to the authors (recipients of the data file) and not to the National Center for Health Statistics which is responsible only for the initial data. None of the authors have any conflicts of interest.

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