Socioeconomic Status and Stroke Incidence in the US Elderly

The Role of Risk Factors in the EPESE Study

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Background and Purpose**—**This study assesses the effect of socioeconomic status on stroke incidence in the elderly, and the contribution of risk factors to stroke disparities.

Methods**—**Data comprised a sample of 2812 men and women aged 65 years and over from the New Haven cohort of the Established Populations for the Epidemiologic Studies of the Elderly. Individuals provided baseline information on demographics, functioning, cardiovascular and psychosocial risk factors in 1982 and were followed for 12 years. Proportional hazard models were used to model survival from initial interview to first fatal or nonfatal stroke.

Results**—**Two hundred and seventy subjects developed incident stroke. At ages 65 to 74, lower socioeconomic status was associated with higher stroke incidence for both education ($HR_{lowest/highest}$=2.07, 95% CI, 1.04 to 4.13) and income ($HR_{lowest/highest}$=2.08, 95% CI, 1.01 to 4.27). Adjustment for race, diabetes, depression, social networks and functioning attenuated hazard ratios to a nonsignificant level, whereas other risk factors did not change associations significantly. Beyond age 75, however, stroke rates were higher among those with the highest education ($HR_{lowest/highest}$=0.42, 95% CI, 0.22 to 0.79) and income ($HR_{lowest/highest}$=0.43, 95% CI, 0.22 to 0.86), which remained largely unchanged after adjustment for risk factors.

Conclusions**—**We observed substantial socioeconomic disparities in stroke at ages 65 to 74, whereas a crossover of the association occurred beyond age 75. Policies to improve social and economic resources at early old age, and interventions to improve diabetes management, depression, social networks and functioning in the disadvantaged elderly can contribute to reduce stroke disparities. **(*Stroke*. 2006;37:1368-1373.)**

Key Words: aged ■ psychology ■ social class ■ stroke ■ United States

Disparities in cardiovascular health are a major public health problem. Eliminating these disparities is one of the major goals of the Healthy people 2010 public agenda, which calls for further research to understand the causes of these disparities.[1] Lower socioeconomic status is associated with higher stroke incidence in European countries.[2–6] However, little research has examined this association in the US and how it varies across age-groups. It is also not well established which risk factors mediate this association. Previous research in the UK suggests that conventional risk factors such as hypertension and smoking explain about half of these disparities.[3] However, these studies were focused on those aged <65.[3] Around 89% of strokes occur after age 65,[7] whereby factors such as depression and functioning are also major risk factors for stroke.[8,9]

We assessed the effect of socioeconomic status on stroke incidence in the US elderly, and the role of risk factors in explaining stroke disparities. Furthermore, we examined the role of race. We used data from a representative sample of the elderly in New Haven followed for 12 years. As relative disparities decrease or disappear at old age,[10,11] we assessed whether this age-pattern applies to stroke. To our knowledge, this is the first study to assess the contribution of biomedical, psychosocial and functioning risk factors to stroke disparities in the elderly, and how this pattern varies for the old and oldest old.

Materials and Methods

Study Population

Data came from the New Haven (Connecticut) sample of the EPESE (Established Populations for the Epidemiologic Studies of the Elderly)

Received October 21, 2005; final revision received January 25, 2006; accepted March 2, 2006.

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Stroke **is available at http://www.strokeaha.org** **DOI: 10.1161/01.STR.0000221702.75002.66**

study, a prospective investigation aimed at identifying predictors of mortality and disability in the elderly. Details of this study have been described elsewhere.[12] The sample was stratified by type of residence: (1) public elderly housing, (2) private elderly housing and (3) general community housing. Because of the preponderance of women, men were oversampled in community and private housing.[12] The response rate was 82%, yielding a baseline sample of 2812 participants. Respondents with a history of stroke at baseline (n=208) or missing basic demographics were excluded. Education data were missing for 73 individuals (2.8%) and income data for 347 participants (13.4%). The final sample comprised 2524 individuals for education and 2250 individuals for income.

Data Collection and Measurements

Interviews were conducted in 1982 by trained interviewers and included information on:

Socioeconomic Status and Demographics

Education and income were used as indicators of socioeconomic status. Education was measured as years of schooling completed (0 to 7, 8 to 9, 10 to 12, or ≥13), and income as household income in the year before baseline (0 to 4999, 5000 to 9999, 10 000 to 14 999, or ≥15 000 US dollars). Race was classified into white non-Hispanic, black non-Hispanic and other. Age was based on self-report and used as a continuous variable.

Conventional Risk Factors

(1) Blood pressure was measured according to the Hypertension Detection and Follow-up Program protocol.[13] A hypertension diagnosis was based on blood pressure measurements or use of hypertension medication. Categories comprised normotensive, controlled, isolated systolic, and diastolic (with or without systolic) hypertension. (2) Smoking was classified into never smoked, exsmoker, and currently smoking daily <14, 15 to 24, and ≥25 cigarettes. (3) Diabetes mellitus was ascertained through self-report at baseline. (4) Body mass index was based on self-reported weight and height (weight [kg]/height [m^2]). (5) Physical activity was measured by self-reported walks, garden work and active sports (scale: often, sometimes and never), and defined as number of items with response category 'often'.[14] (6) Alcohol consumption was based on self-reported use in the preceding month and categorized into: nondrinkers, moderate (0.1 to 20 ounces/month) or heavy (≥21 ounces/month) drinkers.

Physical/Cognitive Functioning

Three complementary measures of physical functioning were used: (1) A modified version of the Katz Activities of Daily Living Scale[15] assessed the ability to perform basic activities without assistance (none versus ≥1 limitations). (2) The Rosow-Breslau Functional Health Scale[16] assessed the number of limitations in activities of gross mobility. (3) The Nagi Scale measured the number of limitations in physical performance activities (eg, difficulty in stooping, crouching and kneeling).[17]

Cognitive function was measured using a 10-item version of the SPMSQ (Short Portable Mental Status Questionnaire)[18] and scored by the number of errors (≤1, 2 to 3, and ≥4).[19]

Psychosocial Risk Factors

(1) Depressive symptoms were measured using the Center for Epidemiologic Studies Depression Scale.[20] A score of 21 or more indicates depressive symptomatology in the elderly.[21] (2) The Social Networks Index measured social ties with children, relatives, friends and a confidant, and social participation.[22] (3) Stressful life events were the summed score of 8 items on stressful events (eg, death of a close relative) during the past year (none, 1, 2, or ≥3).[23]

Stroke Outcomes

An incident event was defined as first nonfatal or fatal stroke. Nonfatal strokes were ascertained through yearly interviews from 1983 through 1990/1991, and in 1994. Education/income information was ascertained at baseline only. Independently, participants were asked in subsequent waves whether they had been diagnosed with stroke since last interviewed. Only 99 survivors (3.9%) did not have complete interviews until 1994, and were censored at last interview date.

Fatal strokes were ascertained through daily review of obituaries, hospital admission records and annual interviews with participant or next of kin. Records were matched to the National Death Index and death certificates obtained. Data on mortality and cause of death were successfully obtained for almost all participants (≥99%).

Methods of Analysis

As results did not differ by sex, men and women were combined to obtain more precise estimates. Firstly, standardized stroke rates were calculated by education and income, using the entire population as the standard. Cox proportional hazard models were then used to quantify the impact of socioeconomic indicators on stroke. Survival was defined as time from baseline to date of first fatal or nonfatal stroke, death from other causes, or last interview. Initial models were adjusted for age, sex and race. Subsequently, conventional, functioning and psychosocial factors were added. Psychosocial factors and functioning measures were correlated. However, correlations were generally modest, so that there was no collinearity in the models. Final models were adjusted for all factors. HRs (hazard ratios) for the reference model (adjusted for age, sex and race) were compared with HRs additionally adjusted for risk factors, using the following formula: $(100\times[HR_{reference}-HR_{adjusted}]/[HR_{reference}-1])$. Analyses were weighted using SUDAAN (version 9.01). Weights permitted the sample characteristics to be inflated to the total New Haven older population, thus assuring the validity of generalizations. We applied housing unit weights, weights to account for male oversampling, and poststratification weights.[12]

Results

During 20 315 person-years, 270 subjects developed incident stroke. Among individuals aged 65 to 74 years, lower socioeconomic status was associated with a higher stroke incidence (Table 1). The standardized stroke incidence rates in those with low education or income were twice as high than in those with high education (HR=2.07, 95% CI, 1.04 to 4.13) or income (HR=2.08, 95% CI, 1.01 to 4.27). A reverse pattern occurred at ages 75 and over, so that stroke incidence rates were higher in the highest education (HR=0.42, 95% CI, 0.22 to 0.79) and income (HR=0.43, 95% CI, 0.22 to 0.86) groups (Table 1).

Adjustment for race attenuated hazard ratios between the highest and lowest socioeconomic groups by about one third (Tables 2 and 3), and confidence intervals became wide and overlapped with the null value. HRs remained largely unchanged after adjustment for hypertension, smoking and alcohol consumption, and adjustment for physical activity and BMI slightly decreased HRs for education but not for income. HRs for both education and income were attenuated after adjustment for diabetes. Accordingly, although most risk factors predicted stroke incidence, only diabetes was clearly associated with socioeconomic status (supplemental Table I, available online at http://stroke.ahajournals.org). Adjustment for all conventional risk factors attenuated the effect of education by 22% and income by 43%, which was almost entirely attributable to diabetes.

Adjustment for depressive symptoms and social networks attenuated HRs considerably for both education and income, whereas life events did not change HRs. Altogether, psycho-

TABLE 1. Stroke Incidence (per 100 000 Person-Years) by Socioeconomic Status Among Men and Women Aged ≥65

Age	Socioeconomic Status	No. Strokes*	Subjects*	Person-Years*	Incidence Rate†	HR† (95% CI)	Trend
65–74							
	Education (y)						*P*=0.06
	Highest (≥13)	17	216	1985.7	641.2	1.00	
	High (10–12)	42	443	3925.2	1104.6	1.74 (0.90–3.38)	
	Middle (8–9)	43	402	3458.5	1089.5	1.67 (0.83–3.34)	
	Low (0–7)	38	366	3228.8	1277.2	2.07 (1.04–4.13)	
	Income (dollars)						*P*<0.05
	≥15 000	12	157	1596.6	667.3	1.00	
	10 000–14 999	16	164	1404.2	844.8	1.30 (0.56–3.06)	
	5000–9999	45	503	4287.3	897.1	1.40 (0.69–2.81)	
	0–4999	49	468	4087.8	1239.4	2.08 (1.01–4.27)	
≥75							
	Education (y)						*P*<0.05
	Highest (≥13)	21	119	811.2	2740.5	1.00	
	High (10–12)	30	264	1741.9	1729.8	0.45 (0.23–0.87)	
	Middle (8–9)	33	325	2236.8	1467.9	0.43 (0.23–0.80)	
	Low (0–7)	36	389	2540.4	1346.7	0.42 (0.22–0.79)	
	Income (dollars)						
	≥15 000	13	60	428.1	3555.7	1.00	*P*<0.05
	10 000–14 999	12	86	570.9	2002.1	0.71 (0.30–1.66)	
	5000–9999	33	374	2393.5	1105.3	0.30 (0.14–0.63)	
	0–4999	46	438	2968.0	1529.5	0.43 (0.22–0.86)	

*Unweighted; † age- and sex-adjusted.

social factors reduced HRs by about 50%. This reflected the consistent association of depression and social networks with education, income and stroke (supplemental Table I). Adjustment for physical and cognitive functioning reduced HRs by about one quarter (Tables 2 and 3). After adjusting for all factors, HRs were no longer significant and decreased by about 60% for education and almost 90% for income.

At ages 75 and over, major risk factors such as hypertension and BMI did not consistently predict stroke (supplemental Table I). Thus, entering risk factors did not change HRs for education or income, which remained well below 1 after adjustment (Table 4).

Discussion

At ages 65 to 74 years, lower education and income were associated with higher stroke incidence. Adjustment for race, diabetes, depressive symptomatology, social networks, and cognitive/physical functioning reduced these associations considerably, whereas other conventional risk factors did not alter associations. Beyond age 75, higher socioeconomic status was associated with higher stroke rates, even after adjustment for risk factors. This suggests a crossover of the association beyond age 75.

Study Limitations

A strength of our study was the long and virtually complete follow-up. However, some limitations should be considered. Mortality was accurately ascertained throughout follow-up. However, nonfatal strokes were ascertained through yearly interviews, which may have resulted in underestimation of stroke incidence. Nevertheless, we found no evidence that underestimation occurred differentially by socioeconomic status. Furthermore, a data audit in the period 1982 to 1988 showed high correspondence between cases detected through interview and hospital records inspection.[24] Thus, any bias caused by this problem is likely to be small.

A majority of the EPESE cohort was retired, with some participants living in elderly housing. Thus, although we asked participants to report income from all household sources, income may not fully reflect all resources available to participants. Thus, we do not know whether a different pattern might be observed for factors such as wealth, which reflect assets accumulation through life.[25]

Data on stroke subtypes were not available in our study. However, previous research indicates that the effect of socioeconomic status is similar for both ischemic and hemorrhagic stroke.[5,6] Nevertheless, future studies should assess whether the role of risk factors in explaining stroke disparities may vary by stroke subtype.

Comparison With Previous Studies

Previous research suggests that conventional risk factors such as smoking explain about half of stroke disparities before age 65.[3] However, we found that these factors play a less

TABLE 2. HRs of Stroke Incidence by Educational Level Among Men and Women Aged 65 to 74

Education (y)	Highest (≥13)	High (10–12)	Middle (8–10)	Low (0–7)
Basic model*	1.00	1.74 (0.90–3.38)	1.64 (0.83–3.34)	2.07 (1.04–4.13)
Race	1.00	1.68 (0.86–3.25)	1.75 (0.78–1.36)	1.74 (0.84–3.58)
Conventional factors†				
Hypertension	1.00	1.71 (0.88–3.31)	1.57 (0.78–3.14)	1.73 (0.85–3.56)
Smoking	1.00	1.74 (0.90–3.38)	1.59 (0.78–3.21)	1.78 (0.86–3.70)
Diabetes mellitus	1.00	1.53 (0.78–3.00)	1.39 (0.68–2.85)	1.62 (0.79–3.36)
Alcohol	1.00	1.69 (0.88–3.24)	1.55 (0.78–3.07)	1.74 (0.85–3.55)
BMI	1.00	1.64 (0.84–3.17)	1.47 (0.72–2.95)	1.62 (0.78–3.36)
Physical activity	1.00	1.57 (0.81–3.07)	1.45 (0.71–2.95)	1.63 (0.79–3.36)
All conventional factors	1.00	1.55 (0.79–3.04)	1.35 (0.68–2.67)	1.58 (0.77–3.26)
Psychosocial factors†				
Depression (cut-off 21)	1.00	1.55 (0.79–3.04)	1.46 (0.72–2.95)	1.52 (0.73–3.15)
Social networks	1.00	1.57 (0.81–3.05)	1.43 (0.71–2.91)	1.54 (0.75–3.15)
Difficult life events	1.00	1.63 (0.83–3.20)	1.55 (0.77–3.12)	1.73 (0.85–3.54)
All psychosocial factors	1.00	1.46 (0.74–2.88)	1.37 (0.67–2.79)	1.37 (0.66–2.83)
Functioning†				
Physical functioning	1.00	1.68 (0.85–3.34)	1.61 (0.79–3.25)	1.62 (0.78–3.37)
Cognitive functioning	1.00	1.68 (0.86–3.26)	1.52 (0.75–3.08)	1.63 (0.79–3.37)
All functioning factors	1.00	1.65 (0.83–3.28)	1.57 (0.78–3.16)	1.55 (0.74–3.25)
Full model	1.00	1.45 (0.72–2.91)	1.31 (0.65–2.65)	1.28 (0.60–2.75)

*Basic model=age+sex; † adjusted for age, sex, race and indicated risk factors.

important role, with only diabetes and less conventional factors contributing to stroke disparities. Accordingly, a previous study indicated that conventional risk factors do not fully explain stroke disparities among elderly women.[4]

Previous research indicates that stroke is associated with depression[9] and low social networks,[9] which highlights their potential role in explaining stroke disparities. Previous studies have also shown that physical functioning limitations

TABLE 3. HRs of Stroke Incidence by Income Among Men and Women Aged 65 to 74

Income (dollars)	High (≥15 000)	10 000–14 999	5000–9999	Low (0–4999)
Basic model*	1.00	1.30 (0.56–3.06)	1.40 (0.69–2.81)	2.08 (1.01–4.27)
Race	1.00	1.23 (0.52–2.88)	1.33 (0.66–2.68)	1.79 (0.87–3.67)
Conventional risk factors†				
Hypertension	1.00	1.22 (0.52–2.89)	1.33 (0.65–2.71)	1.76 (0.85–3.64)
Smoking	1.00	1.19 (0.50–2.80)	1.30 (0.64–2.66)	1.80 (0.87–3.75)
Diabetes	1.00	1.17 (0.50–2.75)	1.16 (0.57–2.36)	1.56 (0.76–3.21)
Alcohol	1.00	1.27 (0.54–2.97)	1.35 (0.68–2.67)	1.80 (0.89–3.64)
BMI	1.00	1.20 (0.51–2.80)	1.26 (0.62–2.57)	1.73 (0.84–3.55)
Physical activity	1.00	1.10 (0.47–2.61)	1.26 (0.61–2.59)	1.72 (0.84–3.53)
All conventional factors	1.00	1.03 (0.43–2.48)	1.07 (0.52–2.21)	1.45 (0.70–3.01)
Psychosocial factors†				
Depression (cut-off 21)	1.00	1.27 (0.54–2.98)	1.28 (0.63–2.58)	1.61 (0.78–3.32)
Social networks	1.00	1.12 (0.47–2.70)	1.18 (0.58–2.39)	1.50 (0.72–3.12)
Difficult life events	1.00	1.22 (0.52–2.87)	1.35 (0.67–2.72)	1.78 (0.87–3.64)
All psychosocial factors	1.00	1.19 (0.50–2.85)	1.17 (0.58–2.36)	1.45 (0.70–3.02)
Functioning†				
Physical functioning	1.00	1.37 (0.57–3.29)	1.34 (0.64–2.80)	1.59 (0.78–3.24)
Cognitive functioning	1.00	1.20 (0.51–2.82)	1.30 (0.64–2.62)	1.75 (0.85–3.58)
All functioning factors	1.00	1.35 (0.56–3.22)	1.32 (0.63–2.74)	1.57 (0.77–3.20)
Full model	1.00	1.03 (0.42–2.55)	0.96 (0.46–2.00)	1.10 (0.52–2.31)

*Basic model=age+sex; †adjusted for age, sex, race and indicated risk factors.

TABLE 4. HRs of Stroke Incidence by Education and Income Among Men and Women Aged ≥75

Socioeconomic Status	Risk Factor	Highest	High	Middle	Low
Education					
	Basic model*	1.00	0.45 (0.23–0.87)	0.43 (0.23–0.80)	0.42 (0.22–0.79)
	Race	1.00	0.45 (0.23–0.89)	0.42 (0.22–0.80)	0.44 (0.23–0.83)
	Conventional†	1.00	0.44 (0.21–0.95)	0.40 (0.20–0.78)	0.45 (0.22–0.92)
	Psychosocial†	1.00	0.49 (0.25–0.95)	0.43 (0.23–0.82)	0.45 (0.24–0.85)
	Functioning†	1.00	0.42 (0.22–0.82)	0.38 (0.21–0.71)	0.39 (0.21–0.73)
	Full model	1.00	0.52 (0.25–1.07)	0.41 (0.21–0.81)	0.47 (0.23–0.94)
Income					
	Basic model*	1.00	0.71 (0.30–1.66)	0.30 (0.14–0.63)	0.43 (0.22–0.86)
	Race	1.00	0.71 (0.30–1.68)	0.31 (0.15–0.64)	0.46 (0.23–0.94)
	Conventional†	1.00	0.71 (0.31–1.66)	0.30 (0.14–0.65)	0.44 (0.22–0.90)
	Psychosocial†	1.00	0.71 (0.30–1.61)	0.30 (0.14–0.63)	0.46 (0.23–0.92)
	Functioning†	1.00	0.77 (0.33–1.81)	0.31 (0.15–0.67)	0.44 (0.21–0.93)
	Full model	1.00	0.82 (0.34–1.93)	0.31 (0.14–0.70)	0.50 (0.24–1.08)

*Basic model=age+sex; †adjusted for age, sex, race and indicated risk factor group: conventional (hypertension, smoking, diabetes, alcohol consumption, BMI and physical activity); psychosocial (depressive symptoms, social networks and difficult life events); and functioning (physical and cognitive).

predict stroke.[8] These factors contributed to stroke disparities in our study. Alternatively, their contribution may also reflect a reverse effect of these factors (eg, physical functioning) on income. However, reverse causality cannot explain results for educational level, which is largely determined early in life.[2]

Socioeconomic disparities in stroke at ages 65 to 74 partly reflect the higher stroke rates among blacks than whites.[26] Blacks have on average less education and income, and are more likely to develop stroke than their white counterparts[26] (supplemental Table I). This is partly explained by a higher burden of risk factors among blacks, and may also reflect genetic susceptibility.[26] However, despite wide confidence intervals, an elevated risk remained after adjustment or stratification by race. Thus, despite large racial stroke disparities, the effect of socioeconomic status on stroke appears to be independent from race.

Prior research reported that stroke disparities diminish but remain beyond age 75.[2] However, our study comprised a longer follow-up and included both first fatal and nonfatal strokes. Studies indicate that the effect of socioeconomic status on all-cause mortality disappear or even reverses at approximately age 75.[11] Our findings suggest that this crossover[10] might be even stronger for stroke.

Interpretation of Findings

Conventional risk factors such as smoking were strong predictors of stroke at ages 65 to 74, but did not explain stroke disparities. This may be attributable to their weak association with socioeconomic status. Accordingly, in earlier birth cohorts, the prevalence of risk factors did not vary as much by socioeconomic status, and only in more recent cohorts do disparities in risk factors such as smoking begin to emerge.[27] Their role in explaining stroke disparities may thus be limited at ages 65 to 74, whereas they may play a more important role in more recent birth cohorts.[3]

On the other hand, socioeconomic disparities in other risk factors played a more important role. Diabetes disparities may originate from differentials in obesity throughout life.[28] Depression is associated with an increased risk of atherosclerosis,[29] through which it may contribute to stroke disparities. Lower social networks are associated with higher functional limitations,[19] which might lead to less physical activity and thus higher stroke rates. However, physical limitations may also be a marker for other health problems, which might mediate the association of socioeconomic status on stroke.

Beyond age 75, higher socioeconomic status was associated with higher stroke rates. Because of their weak association with stroke and socioeconomic status, adjustment for risk factors did not explain this crossover. Failure of education and income to represent the true socioeconomic resources of the oldest old may explain this pattern. Nevertheless, a similar race crossover has also been previously reported, whereby black mortality rates can become lower than white rates after approximately age 75.[10] Selective survival and competing causes of death may explain this pattern. Individuals with lower socioeconomic status may die earlier from other causes, so that only the healthiest survive into old age. Simultaneously, better survival might lead to postponement of death toward older ages among higher socioeconomic groups.[10,11] Thus, higher socioeconomic groups might be more likely to live 'long enough' to develop stroke at very old ages. Nevertheless, previous research indicates that selective survival cannot fully account for age variations in mortality differentials.[11] Further studies should attempt to replicate these findings and explore possible explanations.

Implications

Social and economic circumstances of the elderly shape a wide array of conditions such as stroke. Men and women with a low socioeconomic status face a disproportionate share of social and health disadvantage. Thus, policies aimed at providing both economic and social resources may improve their profile. This can be supplemented with interventions to improve diabetes and depression management, and to maintain social networks and functioning in the lower socioeconomic groups.[19,24] As world populations age, the toll of social and economic disadvantage is likely to increase, along with the societal impact of stroke. Thus, it is incumbent on us to develop effective interventions at middle and early old age, and thus diminish the higher burden of stroke among disadvantaged populations.

Acknowledgments

The Netherlands Organisation for Scientific Research (Nederlandse Organisatie voor Wetenschappelijk Onderzoek -NWO) and the Trustfonds Foundation from the Erasmus University supported this study. Collaboration between the Erasmus MC and the Harvard School of Public Health made possible the conduction of this study. Authors would like to acknowledge the support of the National Institute of Aging (grant #AGO18369) for supporting this work.

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Stroke. 2006;37:1368-1373; originally published online May 11, 2006;
doi: 10.1161/01.STR.0000221702.75002.66
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0039-2499. Online ISSN: 1524-4628