Effect of Area-Based Deprivation on the Severity, Subtype, and Outcome of Ischemic Stroke

Stella Aslanyan, MD; Christopher J. Weir, PhD; Kennedy R. Lees, MD, FRCP; John L. Reid, DM, FRCP, FRSE; Gordon T. McInnes, MD, FRCP, FFPM

Background and Purpose—Markers of low socioeconomic status (deprivation) are associated with stroke and its causes. In the United Kingdom, area-based deprivation measures are available routinely through links with postal codes. We hypothesized that deprivation is associated with ischemic stroke risk factors, severity, subtype, and outcome.

Methods—We studied 2026 patients, each with at least 2 years of outcome follow-up by record linkage after first admission with ischemic stroke to an acute stroke unit. Baseline factors recorded routinely were age, sex, medical history, blood pressure, and stroke severity and subtype. Deprivation was assessed by the Womersley score (WS) and Murray score (MS).

Results—Higher WS and MS were associated with stroke at younger age (eg, WS linear regression coefficient (r) = −0.26; 95% confidence interval [CI], −0.51 to −0.01 per additional point), smoking (odds ratio [OR], 1.12; 95% CI, 1.08 to 1.17), and claudication (OR, 1.09; 95% CI, 1.01 to 1.17); WS was associated with higher systolic blood pressure (r=0.13; 95% CI, 0.02 to 0.24); and MS was associated with severe stroke. Deprivation was not associated with case fatality in univariate analysis or after correction for all baseline factors. Deprivation was associated with readmission to hospital as a result of any vascular event in univariate analysis (hazard ratio [HR], 1.05; 95% CI, 1.02 to 1.09) and after correction for all baseline factors (HR, 1.06; 95% CI, 1.02 to 1.10).

Conclusions—Tackling health inequalities in stroke should focus on stroke primary prevention by tackling deprivation, including promoting changes in lifestyle. (Stroke. 2003;34:0000-0000.)

Key Words: deprivation ■ outcome ■ stroke, ischemic

A acute stroke and disability among stroke survivors are enormous burdens on the social and healthcare systems.1,2 Ischemic stroke, the most common subtype of stroke, is frequent in older individuals and often leads to prolonged hospitalization, disability, or death. It is likely that aging of the population will increase the number of ischemic stroke events in the future. Therefore, its prevention and treatment have considerable public health significance.

Factors that influence health can be categorized into 3 broad groups: (1) factors intrinsic to the individual (genetic factors, biological and ethnic diversity, early life expectancy, lifestyles, and health behavior), (2) factors related to the health service (access to health services and their quality and use), and (3) external factors such as physical environment (air pollution, climate) or socioeconomic status (SES) (local amenities, occupation, income, and housing quality). External factors are closely related to personal behavior and lifestyle.4,5

Deprivation is defined as "a state of observable and demonstrable disadvantage relative to the local community or a wider society or nation to which an individual, family or group belongs."6 Low SES is associated with the risk of stroke.7
We aimed to investigate the relationship between area-based deprivation, assessed by the WS and MS, and stroke baseline severity, subtype, and outcome. We hypothesized that deprivation is associated with (1) more severe stroke, (2) stroke subtype, (3) placement of patients at 1 and 3 months and 2 years, (4) all-cause mortality, (5) higher rates of hospital readmission resulting from any vascular event (RVE) (any ischemic or hemorrhagic vascular event in any vascular territory), and (5) a longer stay in the acute stroke unit.

Subjects and Methods
We studied patients who were consecutively admitted to the Western Infirmary Acute Stroke Unit in Glasgow. Patient data are collected routinely by medical personnel and stored in a database. Institutional guidelines are followed for informing patients about the recording and use of their information. Only anonymous information was examined for the purposes of this study as permitted by local ethics and European data protection guidelines.

We included patients admitted from 1991 to 1998, allowing at least 2 years of follow-up. Sample inclusion criteria were (1) age \(\geq 18\) years, (2) first admission to the acute stroke unit and clinical diagnosis of a new ischemic attack, (3) exclusion of tumor or hemorrhage by cerebral imaging, and (4) categorization by Oxfordshire Community Stroke Project (OCSP) classification\(^7\) as total anterior circulation infarction, partial anterior circulation infarction, posterior circulation infarction, or lacunar infarction confirmed by CT or MRI.

The postal code itself is given by a string of letters and numbers and can be interpreted hierarchically; eg, G11 6SB is Glasgow postal code area G, postal code district 11, postal code sector 6, and postal code unit SB. The postal code sector has a population of \(\approx 5000\) on average, a size sufficient to provide fairly reliable estimation of the rates of common health events.\(^4\) Both deprivation scores used in this study (WS and MS) are based on postal code sector. Some codes are grouped together; eg, all the G1 and G2 areas were merged because each has a small population. Both were created by use of GGNHS area census data on 29 variables (related to the size and ownership or occupancy of housing, car ownership, occupation, social status, and age) using different statistical techniques. The WS is categorical and has 8 clusters, 1 (most affluent) through 8 (most deprived). The MS was associated with younger age, sex, BP, and medical history.

The MS, however, was associated with the baseline mNIHSS score and stroke subtype by OCSP classification. Correcting factors considered were first age and sex and second age, sex, smoking, claudication, and reported alcohol consumption. The MS was associated with younger age, higher systolic BP, smoking, and claudication. The MS was associated with younger age, smoking, claudication, and reported alcohol consumption.

Comparing the linear models with generalized additive models using analysis of variance (ANOVA) assessed the linearity of the relationships between the deprivation scores and dependent variables.

Results
We identified 2748 consecutive admissions from May 1991 to June 1998 with ischemic stroke. Only 2183 (79%) were from the GGNHS area, 2036 (93%) of these being the first admission to the stroke unit of patients \(\geq 18\) years of age. Our sample comprised the 2026 patients who had known stroke outcome.

Figure 1 shows the distribution of the deprivation scores; they have similar shape and are highly correlated (Spearman nonparametric correlation coefficient, 0.79; 95% confidence interval [CI], 0.78 to 0.81). Descriptive statistics on patient age, sex, BP, and medical history and univariate associations with deprivation scores are presented (Table 1). Similar trends were seen with the WS and MS. The WS was associated with younger age, higher systolic BP, smoking, and claudication. The MS was associated with younger age, smoking, claudication, and reported alcohol consumption.

Table 2 presents the distribution of stroke severity, subtype, and outcome. WS was not associated with baseline mNIHSS score in both univariate and multivariate models. Interaction between deprivation scores and age in modeling baseline stroke severity was not significant, but similar analysis of the
1495 patients ≥65 years of age showed stronger relationships between deprivation scores and stroke severity. Deprivation was not associated with stroke subtype, length of stay in the stroke unit, or patient placement at 1 or 3 months or 2 years (dead or in care versus at home) in either univariate or multivariate models (results not presented). From stroke outcome measures, we found a statistically significant association only between deprivation and all-cause mortality and RVE (Table 4). Deprivation assessed by both WS and MS was associated with RVE in all models. The scores were associated with mortality in all models except univariate and after correction for all factors; neither was WS associated with mortality after correction for age, sex, and stroke severity. Figure 2 illustrates the univariate relationship between WS and all-cause mortality and RVE presented as Kaplan-Meier curves. There is no association between mortality and deprivation and a clear gradual increase in RVE with an increase in deprivation.

The linear models presented in the study did not differ significantly from nonlinear, generalized additive models (ANOVA, P > 0.05).

### Discussion

We found that patients living in more deprived areas tend to have ischemic stroke at a younger age, higher baseline systolic BP, and higher rates of stroke risk factors (smoking and claudication). An apparent association between MS and alcohol use was inconclusive as our data did not describe the extent of alcohol use.

Age-standardized first-stroke admission rates increased progressively with deprivation during 1992 to 1996. Accurate population estimates within each postal code sector and rates of referral to our hospital were not available. This study showed, however, that stroke admissions to our hospital occurred at a younger age in patients from deprived areas, implying that cumulative event rates may be even higher.

Patients living in more deprived areas had more severe stroke, with the association being stronger in older patients (≥65 years of age) both in univariate analysis and after correction for other factors that may influence stroke severity. For example, an increase in deprivation from MS 1.5 to 1.5

### Table 2. Distribution of Stroke Severity, Subtype, and Outcome

<table>
<thead>
<tr>
<th>Variables</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline severity, mNINDHSS, median (IQR)</td>
<td>3 (1–7)</td>
</tr>
<tr>
<td>TACI, %</td>
<td>21</td>
</tr>
<tr>
<td>PACI, %</td>
<td>36</td>
</tr>
<tr>
<td>POCl, %</td>
<td>11</td>
</tr>
<tr>
<td>LACI, %</td>
<td>32</td>
</tr>
<tr>
<td>Stay in stroke unit, median (IQR), d</td>
<td>4 (2–6)</td>
</tr>
<tr>
<td>Placement at, % (dead or in care versus at home) 30 d</td>
<td>70</td>
</tr>
<tr>
<td>90 d</td>
<td>59</td>
</tr>
<tr>
<td>2 y</td>
<td>65</td>
</tr>
<tr>
<td>Mortality, %</td>
<td>48</td>
</tr>
<tr>
<td>Readmission because of any vascular event, %</td>
<td>31</td>
</tr>
</tbody>
</table>

TACI indicates total anterior circulation infarction; PACI, partial anterior circulation infarction; POCl, posterior circulation infarction; and LACI, lacunar infarction.
stroke will lead to an increase in stroke severity assessed by the mNIHSS of 1 point (all patients) or of 1.3 points (older patients). We did not find any association between deprivation and ischemic stroke subtype, patient placement at 1 or 3 months and 2 years, or length of stay in a stroke unit.

Patients from deprived areas had higher rates of RVE. This association was found for both scores after full correction for possible confounding factors. The corrected hazard ratio represents a 6% increase in readmission rates per 1-category increase in WS. Overall, the readmission risk between the 2 extremes of WS differs by 56%. Therefore, we conclude that deprivation has an independent effect on readmission to the hospital because of any vascular event. Our data indicate that if Glasgow had the same deprivation profile as Lothian (the second-largest urban area in Scotland, with lower rates than Glasgow of people living in deprived areas), 6.5 hospital admissions resulting from any vascular event would be avoided per 1000 person-years of follow-up after stroke.

Mortality was associated with residence area deprivation only after correction for age and sex and remained significant after correction for all confounding factors except smoking. After correction for smoking, the deprivation effect on mortality was statistically nonsignificant. Thus, studies that correct for only age and sex should be interpreted with caution because the results may be confounded by underlying differences in other factors such as smoking and stroke baseline severity. The point estimate and lower CI limits of deprivation are close to unity; therefore, the significance of any associations between mortality and deprivation may be considered marginal and not clinically significant.

Stroke-standardized mortality ratios rose progressively with increases in deprivation category only for the population <65 years of age in 1991 to 1998.16 This discrepancy between age groups may be attributed to the earlier death of individuals at risk and the increasing mortality from causes other than cerebrovascular disease in people >65 years of age. Other possible explanations include inaccuracy of coding of stroke and underestimation of stroke cases, artifact from the relative insensitivity of deprivation measures in the elderly, and a cohort effect, with older people belonging to a generation for whom deprivation is less of a risk factor for stroke.23 Mortality rates and hazard ratios presented in this study relate to case fatality because they are based on a hospital-based cohort. To investigate whether the reported age discrepancies were due to differences in case fatality, we conducted Cox proportional-hazards modeling of mortality for the subgroup of our sample <65 years of age (n=567). The results were not substantially different from the results for the entire sample.16 In addition, there was no statistically significant association between deprivation and stroke severity in that subgroup. Therefore, we conclude that the discrepancies in mortality presented16 are due to stroke occurring at younger ages in people who live in deprived areas and not to differences in stroke severity or case fatality.

There are limitations in using area-based deprivation scores as a measurement of SES. The scores are based on the assumptions about factors that may represent deprivation; for instance, car ownership may be needed in some households that commute to work or have bigger families and therefore may not represent access to material resources but rather a drain on resources.23 Areas are not internally homogeneous, and sectors containing a mixture of deprived and less deprived households will have a middle ranking.23 The scores from postal code sectors with small populations are more

### TABLE 3. Linear Regression Coefficients (95% CI) of the WS (Per Additional Point) and the MS (Per Increase by 1) When Predicting mNIHSS for the Sample and Subgroup of Patients ≥65 Years of Age

<table>
<thead>
<tr>
<th>Model Information</th>
<th>WS All Patients</th>
<th>≥65 y</th>
<th>MS All Patients</th>
<th>≥65 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Univariate</td>
<td>0.04 (−0.04−0.13)</td>
<td>0.10 (−0.00−0.21)</td>
<td>0.26* (0.00−0.53)</td>
<td>0.45* (0.13−0.77)</td>
</tr>
<tr>
<td>Plus age and sex</td>
<td>0.06 (−0.02−0.15)</td>
<td>0.13* (0.02−0.23)</td>
<td>0.33* (0.07−0.59)</td>
<td>0.56* (0.24−0.88)</td>
</tr>
<tr>
<td>Plus all factors</td>
<td>0.06 (−0.02−0.15)</td>
<td>0.13* (0.02−0.24)</td>
<td>0.34* (0.08−0.60)</td>
<td>0.55* (0.23−0.87)</td>
</tr>
</tbody>
</table>

*p<0.05.

### TABLE 4. Hazard Ratios (95% CI) of the WS (Per Additional Point) and the MS (Per Increase by 1) at the Different Stages of Correction for Baseline Factors

<table>
<thead>
<tr>
<th>Model Information</th>
<th>Readmission Due to Any Vascular Event</th>
<th>All Cause Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WS</td>
<td>MS</td>
</tr>
<tr>
<td>Univariate</td>
<td>1.05* (1.01–1.09)</td>
<td>1.21* (1.08–1.35)</td>
</tr>
<tr>
<td>Plus age and sex</td>
<td>1.05* (1.02–1.09)</td>
<td>1.21* (1.01–1.36)</td>
</tr>
<tr>
<td>Plus severity</td>
<td>1.06* (1.02–1.10)</td>
<td>1.23* (1.10–1.38)</td>
</tr>
<tr>
<td>Plus BP + stroke subtype + medical history†</td>
<td>1.06* (1.02–1.10)</td>
<td>1.24* (1.10–1.39)</td>
</tr>
<tr>
<td>Plus smoking</td>
<td>1.06* (1.02–1.10)</td>
<td>1.23* (1.10–1.38)</td>
</tr>
</tbody>
</table>

*p<0.05.

†History of high BP, transient ischemic attack, stroke, myocardial infarction, angina pectoris, diabetes, high lipid level, atrial fibrillation, alcohol use, claudication, and family history of stroke.
susceptible to small variations. The ecological fallacy is an important potential limitation of area-based measurement because it is based on the false assumption that inferences can be made about individual phenomena on the basis of population observations. Not all deprived individuals live in deprived areas; conversely, many of the less deprived live in very deprived areas. Finally, scores are based on census data updated only every 10 years. Changes in scores may reflect both the true change of the deprivation of the area and the change in relative values of the components. The scores in our study are original: WS is based on 1981 census data and RS is based on 1991 census data. Patients of our sample had stroke from 1991 to 1998, up to 7 to 17 years after the census recording.

Because this study is hospital based, we acknowledge the possibility of selection bias. For example, transient ischemic attack patients might have access to outpatient treatment at a cerebrovascular clinic adjacent to the acute stroke unit; during the time period of our study, 213 such patients would have met the inclusion criteria of this study. They had the same median WS and were not significantly less deprived on the MS. In addition, more affluent patients may rarely attend a private hospital, or deprived patients may conceivably have dismissed stroke symptoms. Overall, we believe that our sample is not severely biased against deprivation.

This study has several strengths. Detailed patient information allows correction for factors such as history of high BP, transient ischemic attack, stroke, myocardial infarction, angina pectoris, diabetes, high lipid level, claudication, atrial fibrillation, stroke family history, smoking, alcohol consumption, BP, stroke severity, and stroke subtype. This study has reliable follow-up because of record linkage (only 1% of missing outcome data) and good-quality data collected prospectively and routinely by trained personnel. Area-based deprivation is currently the only available measure of SES recorded and stored on a regular basis and therefore enables research with a large sample size.

In conclusion, area-based deprivation is associated with stroke risk factors and with stroke at younger age. Deprivation has an independent effect on baseline stroke severity and RVE. Deprivation does not independently affect case fatality, and the inequality is linked mostly to smoking and stroke severity. Tackling health inequalities in stroke should focus on primary prevention of stroke by improving the SES of the disadvantaged population through promoting changes in lifestyle.

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References
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