The Greater Cincinnati/Northern Kentucky Stroke Study
Preliminary First-Ever and Total Incidence Rates of Stroke Among Blacks

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Background and Purpose—The Greater Cincinnati/Northern Kentucky Stroke Study was designed to be the first large, population-based metropolitan study of temporal trends in stroke incidence rates and outcome within a biracial population.

Methods—We are identifying all hospitalized and autopsied cases of stroke and transient ischemic attack (TIA) among the 1.3 million inhabitants of a five-county region of Greater Cincinnati/Northern Kentucky for the period 7/1/93–6/30/94. We have already prospectively monitored for out-of-hospital stroke and TIs at this same time period at 128 screening sites, including a random sample of all primary care physicians and nursing homes in the region. We have already identified all hospitalized and autopsied cases of stroke and TIA among blacks for 1/1/93–6/30/93 and report preliminary incidence rates for this 6-month period.

Results—The overall incidence rate for all first-ever hospitalized or autopsied stroke (excluding TIAs) among blacks in the Greater Cincinnati region was 288 per 100 000 (95% CI, 250 to 325, age- and sex-adjusted to 1990 US population). The overall incidence rate for first-ever and recurrent stroke (excluding TIAs) was 411 per 100 000 (95% CI, 366 to 456). By comparison, the overall incidence rate of first-ever stroke among whites in Rochester, Minn, during the period 1985–1989 was 179 per 100 000 (95% CI, 164 to 194, age- and sex-adjusted to 1990 US population). The incidence rates among blacks in Greater Cincinnati were substantially greater than the rates among whites in Rochester, Minn, for all age categories except ages 75 and older, for which the rates were similar.

Conclusions—We conservatively estimate that 731 100 first-ever or recurrent strokes occurred in the United States during 1996. Studies of first-ever as well as total stroke among biracial and representative populations are critical for understanding temporal trends in the incidence rate and the burden of stroke in the US population. (Stroke. 1998;29:415-421.)

Key Words: cerebral infarction ■ epidemiology ■ intracerebral hemorrhage ■ racial differences ■ subarachnoid hemorrhage

The population of Rochester, Minn, has provided the only data addressing temporal trends in the incidence rate of stroke in the United States over the past 45 years. However, the small, affluent, nearly all-white Rochester population contains only 1% blacks and is not representative of the entire US population (Table 1). Stroke mortality rates in Rochester are lower than elsewhere in the United States, and the decline in stroke mortality rates in Rochester before 1980 was more rapid than that in the United States as a whole. Thus, temporal trends in stroke incidence and mortality rates seen within the nearly all-white and affluent Rochester population of 70 000 may not reflect trends within the US population, particularly among the minority populations of blacks, Hispanics, and Asians. Larger population-based studies of temporal stroke trends are needed that complement the Rochester database and include a substantial proportion of blacks or other minority populations.

The Greater Cincinnati/Northern Kentucky Stroke Study was designed to be the first large, population-based metropolitan study of temporal trends in stroke incidence rates and outcome within a biracial population. Our population is similar to that of the United States in terms of age, economic status, and proportion of blacks (Table 1). Previous community studies using this population have included studies of carotid endarterectomy, ICH, SAH, and stroke in children. The present population-based study includes all hospitalized and autopsied stroke patients as well as a sample of all out-of-hospital strokes during 1993 to 1994.

The unique methodology for this study as well as the first 6 months of case ascertainment and data analysis among hospitalized or autopsied blacks are presented in this report.
Selected Abbreviations and Acronyms

CI = confidence interval
ICD-9-CM = International Classification of Diseases, 9th Revision, Clinical Modification
ICH = intracerebral hemorrhage
SAH = subarachnoid hemorrhage
TIA = transient ischemic attack

Subjects and Methods

Study Population

The study population is defined as all residents of the Greater Cincinnati/Northern Kentucky region, which includes two southern Ohio counties and three contiguous Northern Kentucky counties that abut the Ohio River (Fig 1). Most persons in Ohio, Kentucky, and southeastern Indiana who live in counties adjacent to the defined study region also receive hospitalized medical care at the 19 study hospitals within the Greater Cincinnati/Northern Kentucky study region. However, residents of these surrounding counties are not included as cases. Past surveys of stroke admissions at the closest hospitals outside of the study region demonstrated no patients with ischemic or hemorrhagic stroke who were residents of our defined five-county study region.7

Screening for Hospitalized and Autopsied Strokes

A study nurse reviewed the medical records of all persons who were discharged from one of the 19 acute-care hospitals in the study region (Fig 1) from 7/1/93 to 8/1/94 with an ICD-9-CM code (primary or secondary discharge diagnoses) of 430 (SAH), 431 (ICH), 432 (other and unspecified intracranial hemorrhage), 433 (occlusion and stenosis of preoccural arteries), 434 (occlusion of cerebral arteries),435 (TIA), 436 (acute but ill-defined cerebrovascular disease), 437 (other and ill-defined cerebrovascular disease), 438 (late effects of cerebrovascular disease), 747.81 (anomalies of the cerebrovascular system), 674.0 (cerebrovascular disorders in the puerperium), or 325 (phlebitis and thrombophlebitis of intracranial venous sinuses). All primary and secondary discharge diagnoses listed for a potential patient were used in the screening process. The screening lists generated from hospital data systems excluded most potential cases who resided at zip codes outside of the study region. Because discharge diagnoses were used to screen for potential cases, the additional 2 months of screening ensured inclusion of stroke patients who had the onset of stroke within the study year but who were discharged after the study year had ended. To ensure an adequate number of cases of stroke among different age subgroups among the black population, the study nurses also examined the medical records of all black patients with the same ICD-9-CM discharge diagnoses for the period 1/1/93–6/30/93. Thus, on completion of the study, we will have screened for strokes among whites for 1 year and among blacks for 1 1/2 years.

The study nurses also reviewed all autopsied cases from the coroner’s offices of the five study counties from 1/1/93 to 12/31/94 with stroke listed as a primary or secondary cause of death. In addition, we obtained from the Ohio and Kentucky departments of vital statistics the death certificates for all residents of the five Ohio and Kentucky counties who died during the period 1/1/93–2/28/95 and had stroke listed as a primary or secondary cause of death.

Nonhospitalized, Nonautopsied Stroke Cases

Because the labor and cost of identifying all out-of-hospital strokes among 1.3 million people are prohibitive, we estimated the number of nonhospitalized stroke cases by prospectively monitoring all stroke or TIA-related diagnoses at the following health care settings: (1) all Cincinnati and Northern Kentucky Public Health Clinics during 7/1/93–8/31/94 (90 000 visits); the Cincinnati Public Health Clinics serve approximately 15% of the city of Cincinnati population, including much of the indigent population; (2) all hospital-based outpatient visits at the University of Cincinnati medicine and neurology outpatient clinics (26 000 visits); (3) seven University of Cincinnati affiliate family practice centers (101 000 outpatient visits); (4) the neurology and general medicine clinics at the Veterans Administration Medical Center (33 500 visits); (5) the general medicine clinics at Good Samaritan Hospital (3900 visits), The Christ Hospital (5750 visits), and Jewish Hospital (6400 visits); and (6) the family medicine residents clinics at St Elizabeth Hospital (20 100 visits) and Bethesda Hospital (14 000 visits).

We also randomly selected 50 of the 878 family medicine physicians and internists in the five-county region (identified from all names in the Greater Cincinnati/Northern Kentucky Yellow Pages). Only two physicians refused to participate in the study. The study was discussed with each physician and his or her office staff. A study form was given to the office staff to record the names of any potential cases of stroke or TIA. A study nurse called the physician’s office staff monthly to check whether any new stroke cases had been detected. If potential cases were noted, the study nurse abstracted the medical record. Two large groups of primary care physicians provided us estimates of the average annual number of patient visits per physician (approximately 3700 outpatient visits per year). Thus, our screening of 50 physicians represents screening of approximately 185 000 annual visits.

In addition, a 15% sample of the 193 nursing homes in the five-county region was selected randomly (total number of participating nursing home beds during 1993–1994 was 2702). Only four nursing homes that were contacted refused to participate in the study. The study was discussed in detail with the head nurse/administrator at each nursing home. A study form was posted to record potential cases. Each nursing home was contacted every month for identification of potential cases. After a release of information form was signed, the study nurse reviewed and abstracted the nursing home records. Finally, all emergency department visits during the study year were screened by review of emergency department logs at all 18 regional adult hospitals.

All cases of stroke in our database are cross-matched with vital statistic data from the states of Ohio and Kentucky as well as the US Death Index database to determine long-term survival status.

Abstraction of Clinical and Imaging Data From the Medical Records

The study nurse wrote a short summary of the presenting stroke symptoms and physical findings at the time of first medical evaluation of the potential stroke. An NIH Stroke Scale score was estimated by the study nurse from the physician examination. Detailed information was abstracted from the medical record regarding demographics, prior medical history, medications taken before stroke, prehospital evaluation, emergency department evaluation, neurological evaluation, admission vital signs and cardiac examination, neurological evaluation, diagnostic tests, treatments, outcome, type of insurance, and current address. (The address identified which census tract to consult for population demographic information, eg, mean education level and mean income.) All data were directly entered into a laptop computer at the site of medical record review. The study nurse recorded the source of the information and made a determination of whether a stroke or TIA had occurred. The study nurses were instructed to include all borderlne cases and frequently review difficult cases by telephone with a study physician.

| TABLE 1. Comparison of the Greater Cincinnati, Rochester (Minn), and US Populations by 1990 US Census Tract Data |

<table>
<thead>
<tr>
<th></th>
<th>Greater Cincinnati</th>
<th>United States</th>
<th>Rochester, Minn</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of people</td>
<td>1,299,901</td>
<td>248 million</td>
<td>70,745</td>
</tr>
<tr>
<td>Median age, y</td>
<td>32.4</td>
<td>32.9</td>
<td>31.5</td>
</tr>
<tr>
<td>Black, %</td>
<td>14%</td>
<td>13%</td>
<td>1%</td>
</tr>
<tr>
<td>Median household income</td>
<td>30,691</td>
<td>29,943</td>
<td>34,922</td>
</tr>
<tr>
<td>Below poverty level, %</td>
<td>11%</td>
<td>11%</td>
<td>7%</td>
</tr>
</tbody>
</table>
After the nurse completed abstraction of a study case, the computer files were downloaded into another portable computer to be reviewed by the study neurologist. The neurologist reviewed the database for each case as well as all associated CT, MR, and angiographic reports and films, noting the location of any lesions on CT and/or MR brain imaging that were consistent with the clinical presentation. Using all clinical and radiographic information, the study neurologist made the final determination of whether the patient met the criteria for a stroke or TIA and also determined the subtype of stroke and TIA.

Case Criteria
To qualify as an incidence case, a person must have met criteria for one of the five stroke/TIA subcategories listed in Appendix 1, lived at a zip code within the five-county region at the time of stroke onset, and had the onset of stroke between 1/1/93 and 6/30/94 for blacks and between 7/1/93 and 6/30/94 for whites. The criteria that define the various diagnostic categories of stroke, including ischemic stroke subtypes, were adapted from the Classification of Cerebrovascular Diseases III and from epidemiological studies of stroke in Rochester, Minn. Strokes were classified as first-ever or recurrent based on evidence of prior clinical stroke in the written history and physical examination of the admitting physician, emergency department physician, consulting neurologist, and nurse. The date and type of each prior stroke or TIA were recorded, and any neurological deficit that was present before the current stroke or TIA was documented. Cases of first-ever stroke by history whose imaging studies indicate an additional old “silent” cerebral infarct were classified as a first-ever cerebral infarction for incidence-rate calculations. Grounds for excluding potential cases of stroke were the following: (1) the patient had no clinical history of stroke, and the only evidence of stroke was a diagnosis on the death certificate, an area of low density on a head CT scan, or an old lesion in the brain at autopsy; (2) the patient had a clinical diagnosis of stroke and died within 24 hours of the onset of symptoms but had no focal neurological deficit, no autopsy, and no head CT scan. All excluded cases and the reason for exclusion were recorded. Recurrent strokes were classified as per the criteria for first stroke. Cases that met criteria for cerebral infarction were sorted by the operational categories listed in the Appendix. A patient could qualify for one or several of the six categories of cerebral infarction (for instance, a patient may have had a potential cardiac source of embolism and ≥50% stenosis of an appropriate extracranial carotid artery). In cases that met criteria for more than one category, the study physician made a final judgment about the most likely cause of cerebral infarction.

Calculations and Comparison of Incidence Rates
The denominators for incidence-rate calculations were based on linear extrapolations of county populations in race, sex, and age subcategories for the years 1993 and 1988. The 1980 and 1990 US Census population figures for each of the five counties by race, age, and sex were used to calculate the linear function.

Incidence rates were calculated for each age, sex, and race category. For comparison with other studies, including the 1988 Cincinnati study of ICH and SAH and the 1985 to 1989 stroke incidence study.

Figure 1. Map of the five-county study region, with hospital and out-of-hospital screening sites.

Figure 2. Age-specific incidence rates of first-ever stroke among blacks in Greater Cincinnati during the first 6 months of 1993 and among whites in Rochester, Minn, during 1985–1989.
in Rochester, Minn, the incidence rates for all stroke and for each stroke subtype were adjusted to the 1990 US population. Only cases of first-ever stroke were included unless specifically noted. For calculation of preliminary incidence rates among blacks for the period 1/1/93–6/30/93, only cases of hospitalized and autopsied stroke or TIA were used. The 95% CIs for the incidence rates were calculated using a Poisson distribution. The 95% CI for the difference in rates by race, gender, etc., incorporate a pooled estimate of the variance in the incidence rates.\(^4\)

**Results**

During 1/1/93–6/30/93, we reviewed records of 1003 black patient encounters at the 19 regional hospitals and five coroners’ offices that were coded as potential strokes or TIAs. Of the 1003 encounters, 733 occurred in blacks who were residents of the study region and had their event during 1/1/93–6/30/93. Of the 733 encounters, 332 blacks had 351 events that led to hospitalization or autopsy and met the criteria for a stroke or TIA during the study period after review of all clinical and imaging data by the study physicians. Of the 332 subjects with a stroke or TIA, 213 had a first-ever stroke (prior TIA allowed) and 27 a first-ever TIA. The 213 persons with a first-ever stroke had the following stroke subtypes: cerebral infarction, 179 (84%); ICH, 21 (10%); SAH, 8 (4%); intraventricular hemorrhage, 1 (0.5%); and unspecified type, 4 (2%). Two additional subjects with a first-ever cerebral infarction had a prior ICH, and 5 with a first-ever cerebral infarction had a prior stroke of unknown type. These 7 subjects with a prior stroke of unknown type or ICH are not included as first-ever strokes, but the 2 cases with a prior ICH are included in the incidence rates of first-ever cerebral infarction. Similarly, 6 of the 27 subjects with a first-ever ICH and 1 of the 9 subjects with a first-ever SAH had a prior cerebral infarction and are not included as first-ever strokes, but they are included in the incidence rates of first-ever ICH or SAH. One patient had a recurrent ICH and is not included in the incidence rate of first-ever stroke or first-ever ICH.

Of the 213 first-ever stroke cases (excluding TIAs), 209 patients (98%) had a CT scan (93%) or MRI (22%) of the brain or an autopsy of the brain (1.4%), and 61% had a neurologist who was involved with their hospital care. Of the 213 first-ever stroke cases, 30% of the patients had a decrease in the level of consciousness, 75% had motor weakness or incoordination, and 63% had speech or language problems as part of their presenting symptoms. Twenty-four percent of the 198 patients with a first-ever stroke who had a head CT scan as part of their diagnostic evaluation had a “silent” infarct outside of the distribution of their presenting stroke.

The overall incidence rate for all first-ever stroke among blacks in the Greater Cincinnati region during the first 6 months 1993 was 288 per 100 000 (95% CI, 250 to 325, age- and sex-adjusted to 1990 US population, excludes TIA). The incidence rate of all stroke (first-ever and recurrent stroke, excludes TIA) for blacks in Greater Cincinnati during the first 6 months of 1993 was 411 per 100 000, (95% CI, 366 to 456, age- and sex-adjusted to the 1990 US population). By comparison, the overall rate of first-ever stroke among whites in Rochester, Minn, during 1985–1989 was 179 per 100 000 (95% CI, 164 to 194, age- and sex-adjusted to 1990 US population).\(^1\)\(^2\) The incidence rates among blacks in Greater Cincinnati during 1993 were substantially greater than those among whites in Rochester, Minn, during 1985 to 89 for all age categories except for ages 75 and older, in which the rates were similar (Fig 2).

Our preliminary analysis comparing the incidence rates of hemorrhagic stroke among African Americans in Greater Cincinnati during first 6 months of 1993 with rates among blacks during 1988 (both incidence rates age- and sex-adjusted to the 1990 US population) indicate that the rate of SAH during the first 6 months of 1993 (11 per 100 000; 95% CI, 3 to 18) remained similar to the rate during 1988 (11 per 100 000; 95% CI, 6 to 16). The rate of ICH during the first 6 months of 1993 (38 per 100 000; 95% CI, 25 to 52) increased significantly from the rate among blacks in Greater Cincinnati during 1988 (18 per 100 000; 95% CI, 11 to 24). The incidence rate of first-ever cerebral infarction among blacks for the first 6 months of 1993 was 246 per 100 000; 95% CI, 211 to 280.

The final diagnosis of the study nurses and the final diagnosis of the physician agreed in 83% of potential cases. Only two of the 38 cases (37 first-ever, 1 recurrent) of hemorrhagic stroke were classified as ischemic stroke by the nurses. One of the two patients was coded as ICD-9-CM 436 (acute but ill-defined cerebrovascular disease) and the other 435 (TIA). The initial CT (1 patient) and MRI (1 patient) reports in the chart did not mention hemorrhage and differentiation between the diagnosis of brain hemorrhage versus hemorrhagic infarction was not clear in the medical record. After review of the films by the study physician, both subjects clearly had a primary intracerebral hemorrhage (one large, one small). In 20 cases, the nurses judged a stroke or TIA to have occurred whereas on final review the physician investigator did not. Almost all of these cases had acute change in central nervous system function (eg, change in level of consciousness), but the physician judged that the symptoms were not focal enough to meet the strict definition of a stroke. The only other area of some disagreement was the distinction between TIA and ischemic stroke in which the question of duration of symptoms and signs (>24 hours or <24 hours) was the difficult issue. The accuracy and yield of ICD-9-CM codes for the first 6 months of potential black cases of stroke and TIA are presented in Table 2. If we use only primary and secondary ICD-9-CM codes 430–436, we would detect 97% of all strokes and TIs and the true positive rate for stroke is 72±2%. Only 9 of 351 strokes were identified by ICD-9-CM codes 437–438, but these codes represented 39% of record reviews. Using only primary discharge diagnoses of ICD-9-CM codes 430–436, increases the true positive rate to 83±2%, but decreases the yield of cases of stroke and TIA to 84%.

**Discussion**

The incidence rate of first-ever hospitalized or autopsied stroke among blacks the Greater Cincinnati population during 1993 was 1.6 times greater than the overall age- and sex-adjusted incidence rate of stroke among the white population of Rochester, Minn, during 1985–1989. These data indicate that studies of biracial populations are critical for determining the true incidence rate and burden of stroke in the United States population. In addition, the difference in incidence rates between blacks and whites is an underestimate for two reasons.
TABLE 2. Accuracy and Yield of ICD-9-CM Codes (Primary and Secondary Discharge Codes*) for All 337 Black Hospitalized and Autopsied Subjects With Stroke or TIA During 1/1/93-6/30/93

<table>
<thead>
<tr>
<th>ICD-9-CM Code</th>
<th>No. of Record Reviews</th>
<th>True-Positive Rate for Stroke, %±SE</th>
<th>% of All Stroke/TIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>430</td>
<td>14</td>
<td>64±18</td>
<td>3</td>
</tr>
<tr>
<td>431</td>
<td>30</td>
<td>83±7</td>
<td>8</td>
</tr>
<tr>
<td>432</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>433</td>
<td>26</td>
<td>35±10</td>
<td>3</td>
</tr>
<tr>
<td>434</td>
<td>187</td>
<td>80±3</td>
<td>43</td>
</tr>
<tr>
<td>435</td>
<td>69</td>
<td>83±5</td>
<td>16</td>
</tr>
<tr>
<td>436</td>
<td>117</td>
<td>64±4</td>
<td>22</td>
</tr>
<tr>
<td>437</td>
<td>66</td>
<td>12±4</td>
<td>2</td>
</tr>
<tr>
<td>438</td>
<td>218</td>
<td>2±1</td>
<td>0</td>
</tr>
<tr>
<td>430-438</td>
<td>733</td>
<td>46±2</td>
<td>100</td>
</tr>
</tbody>
</table>

*No subjects had ICD-9-CM discharge code 325 (phlebitis and thrombophlebitis of intracranial venous sinuses) or 674.0 (cerebrovascular disorders in the puerperium); one subject had discharge code 747.81 (anomalies of cerebrovascular system) but did not meet criteria for stroke or TIA.

First, outpatient strokes among blacks were not included in the first 6 months of our ongoing study in Greater Cincinnati. Second, the denominators used for calculations of the Rochester incidence rates subtract the estimated prevalence of persons who already have had a stroke. Because the prevalence of stroke in Rochester among the elderly is appreciable (eg, approximately 10% in persons 85 years and older),1 the incidence rates in the oldest age groups are proportionally increased. Such prevalence estimates are not yet available for the Greater Cincinnati population.

Blacks in Greater Cincinnati under the age of 65 had a two to four times greater incidence rates of first-ever stroke compared with rates among whites of similar age in the Rochester population. Age-specific stroke incidence rates were similar for elderly blacks and whites. These differences between blacks and whites with respect to stroke incidence rates mirrors the differences in stroke mortality rates between blacks and whites in the US population.15 Possible explanations for the much higher stroke incidence rates among blacks include a higher prevalence of hypertension,16,17 higher rates of smoking among young blacks,16,17 a higher prevalence of diabetes,20 and a lower and more stressful socioeconomic lifestyle.20 However, at least 50% of the large age-related differences in incidence rates among blacks and whites has yet to be explained.20

The incidence rate of total stroke (excluding TIAs) was 43% greater than that of first-ever stroke among blacks in the Greater Cincinnati population. The epidemiology of total stroke, that is, first-ever stroke and recurrent stroke, is understudied and yet is a better index of the overall burden of stroke in the population. Since the methods of data collection as well as the documentation of prior deficits in the medical record vary among community-based stroke studies, ascertainment of a history of prior stroke will also vary among these epidemiological studies of stroke incidence rates. One way to compare the accuracy of historical information concerning prior stroke among various community studies is to compare the frequency of “silent” infarcts on baseline CT scans that were obtained to evaluate the presenting strokes. Our 24% rate of “silent” infarcts on the baseline CT in patients with a first-ever stroke is lower than rates reported for two other population-based studies of hospitalized first-ever strokes in Copenhagen (29%) and Umbria, Italy (38%), during the CT era.21,22

The American Heart Association’s 1997 Heart and Stroke Statistical Update states that approximately 500 000 Americans suffer a first-ever or recurrent stroke each year.23 This statement is based on the all-white cohort study of Framingham, Mass. Our incidence data indicate that the figure of 500 000 strokes substantially underestimates the actual stroke burden for the United States. Application of our total stroke incidence rates among blacks to the projected 1996 black population of the United States would indicate that there were approximately 138 100 strokes among blacks in the United States during 1996. The recurrence rate of stroke among whites in the Rochester population is not known (personal communication, Dr Robert Brown, Mayo Clinic, 1997). However, if we assume that the ratio of first-to recurrent stroke for whites in Rochester is similar to that for blacks in Greater Cincinnati, we would expect that the incidence rate of total stroke in Rochester, Minn, would be 256 per 100 000 population or 43% greater than the incidence rate of first-ever stroke. Application of this rate of total stroke to the remainder of the 1996 United States population would indicate that there were 593 000 strokes among whites and nonblack segments of the population during 1996. Thus, we conservatively estimate that there were 731 100 first-ever or recurrent strokes in the United States during 1996. This figure is probably an underestimate, since it assumes that stroke incidence rates among the affluent middle- to upper-class whites of Rochester are similar to stroke incidence rates among all whites, Hispanics, Asians, and other ethnic populations in the United States.

Many epidemiological studies utilize ICD-9-CM stroke-related discharge codes as surrogate markers for incidence cases of stroke. Our data indicates that studies which use primary and secondary ICD-9-CM discharge codes 430 to 438 to measure stroke occurrence will overestimate the number of hospitalized strokes in the population by a factor of 2. ICD-9-CM discharge codes 430 to 436 provide nearly complete ascertainment of hospitalized strokes but still overestimate stroke occurrence by 39%. Using only primary discharge diagnosis of ICD-9-CM codes 430 to 436 increases the true positive rate for stroke or TIA from 72% to 83% but decreases the yield of cases of stroke and TIA from 97% to 84%. Thus, primary stroke-related discharge diagnoses 430 to 436 probably provide the best estimate of the true incidence rate of hospitalized stroke and could be used to estimate temporal trends in the incidence rate of hospitalized stroke within a given community. This observation assumes that coding practices remain unchanged over time and that investigators understand the limitations of this method.

The Greater Cincinnati population is similar to the United States population and results from our study are likely generalizable to the populations of whites and blacks in the United States as a whole. By replication of our study methodology every 5 years, we intend to study the relation between...
temporal trends in stroke incidence rate and outcome and advances in the treatment of stroke, the prevalence of stroke risk factors within the population, and the knowledge of stroke warning signs and stroke risk factors in the population. Such data will be critical for development of public health strategies and new clinical trials that seek to further decrease the mortality and morbidity due to stroke.

Appendix 1
Criteria for Stroke and Stroke Subtypes

I. Cerebral Infarction:
A relatively rapid onset of focal neurological deficit with signs or symptoms persisting longer than 24 hours and not attributable to another disease process. Patients who \( \geq 24 \) hours after the onset of stroke have only persistent sensory symptoms with minimal sensory signs or mild impairment of dexterity with normal muscle strength are included. CT of the head need not show an appropriate focal area of decreased attenuation, but will show an area of increased density only in cases with a hemorrhagic transformation of a cerebral infarction. Data from MRI are also reviewed and used if available.

A. Cerebral infarction associated with a major cardiac source of emboli
[Rochester criteria 13] This category includes myocardial infarction within 6 weeks of stroke onset; acute congestive heart failure; mitral stenosis confirmed by clinical examination, echocardiography, or autopsy; artificial heart valve; atrial fibrillation or atrial flutter on electrocardiography; thombus in the atrium, ventricle, or on the aortic or mitral valve identified by echocardiography or coronary angiography; left ventricular aneurysm identified by echocardiography or coronary angiography; sick sinus syndrome identified by monitoring of cardiac rhythm. Patients with an akinetic or hypokinetic wall segment by echocardiogram are also included.

B. Cerebral infarction associated with significant atherosclerotic disease in an appropriate extracranial artery
This means \( \geq 50\% \) stenosis of the internal carotid artery by carotid ultrasound/duplex studies or \( \geq 50\% \) diameter stenosis of the extracranial carotid, vertebral, or basilar arteries by angiography in at least one plane.

C. Cerebral infarction associated with significant intracranial arterial disease
This is defined as occlusion or partial occlusion (\( \geq 50\% \) diameter stenosis by angiogram or MR angiography) of the intracranial carotid, vertebral, or basilar arteries; the basilar; or the middle, anterior, and posterior cerebral artery trunks. Distinction between resolving embolism and primary disease of the intracranial vessel will be made by the neuroradiologist.

D. Cerebral infarction in the distribution of a small artery or arteriole
[Either condition a, b, or c is true] Condition a: Brain images show a deep infarct of \( \leq 1.5 \) cm. in its maximal diameter that is appropriate to the clinical and sensory loss involving the entire hemiface and hemibody or the hemibody alone. There may be incidental motor weakness from another cause. Ataxia-hemiparesis: Hemiparesis with ipsilateral ataxia. Paresis is more commonly crural. Dysarthria–clumsy hand syndrome: Dysarthria with a clumsy hand. Facial weakness is possible. Hemiballismus, hemiatrophia, or hemidystonia: Must be of acute onset. Sensomotor stroke: Weakness and sensory loss involving face, arm, and leg equally, without other neurological findings. Condition c: CT scan shows a deep infarct of \( <1.5 \) cm in its maximal diameter that is appropriate to the clinical syndrome, but the syndrome is not one of the classical syndromes for lacunar stroke.

E. Cerebral infarction associated with another identified cause of stroke

F. Cerebral infarction of uncertain cause

II. Intracerebral Hemorrhage:
Nontraumatic abrupt onset of severe headache, altered level of consciousness, and/or focal neurological deficit that is associated with a focal collection of blood within the brain parenchyma on CT or at autopsy and is not due to trauma or hemorrhagic conversion of a cerebral infarction. Cases of intraventricular hemorrhage without ICH or SAH will be classified as ICH unless angiography demonstrates an aneurysm.

III. Subarachnoid Hemorrhage:
Nontraumatic abrupt onset of severe headache or altered level of consciousness that is associated with blood in the subarachnoid space on CT or at autopsy, or a clinical history and examination consistent with SAH (sudden onset of severe headache or altered level of consciousness), with xanthochromia and many red blood cells in the cerebrospinal fluid. Cases that have both ICH and SAH are classified as SAH if an aneurysmal source of bleeding is documented or if the neuroradiologist suspects a subarachnoid origin of the bleeding. Cases are classified as ICH if a parenchymal source of bleeding seems most likely.

IV. Stroke of Uncertain Type:
Relatively rapid onset of a major focal neurological deficit that persists \( >24 \) hours is fatal and cannot be attributed to another cause. This category is used when radiographic or pathological information is insufficient to distinguish among cerebral infarction, ICH, and SAH.

V. Transient Ischemic Attack:
Acute focal neurological signs and symptoms that last \( <24 \) hours. Patients with transient symptoms that are associated with an appropriate lesion on CT scan or MRI will be noted but not included as an incidence case of cerebral infarction.

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References
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