Background and Purpose—Timely access to medical treatment is critical for patients with acute stroke because acute therapies must be given very quickly after symptom onset. We examined the effect of socioeconomic status on prehospital delays in stroke and transient ischemic attack (TIA) patients within a large, biracial population.

Methods—By screening all local hospital ICD-9 codes 430 to 436, all stroke and TIA patients were identified during the calendar year of 1999. Cases must have used emergency medical services (EMS), lived at home, had their stroke at home, and had documented times of the 911 call and arrival to the emergency department. Socioeconomic status was estimated using economic data regarding the geocoded home residence census tract.

Results—Only 38% of stroke and TIA patients used EMS. There were 978 cases of stroke and TIA included in this analysis. The mean times were call to arrival on scene 6.5 minutes, on-scene time 14.1 minutes, and transport time 13.1 minutes. Lower community socioeconomic status was associated with all 3 EMS time intervals; however, all time differences were small: the largest difference was 5 minutes.

Conclusions—Within our population, living in a poorer area does not appear to delay access to acute care for stroke in a clinically significant way. We did find small, statistically significant delays in prehospital times that were associated with poorer communities, black race, and increasing age. However, delays related to public recognition of stroke symptoms, and limited use of 911, are likely much more important than these small delays that occur with EMS systems. (Stroke. 2006;37:1508-1513.)

Key Word: epidemiology
study population for the GCNKSS is defined as all residents of the Greater Cincinnati metropolitan region, which includes 2 southern Ohio counties and 3 contiguous Northern Kentucky counties that border the Ohio River. Included in this area are 18 hospitals. These hospitals are distributed throughout the region, in communities of widely varying socioeconomic status (see Figure 1). All hospitals in the region are covered by a single group of stroke-team physicians; therefore, all hospital ED have access to the same expert stroke care, and patients in the region are not routinely diverted large distances to tertiary centers for acute care. The study population is ~1.3 million residents, with a percentage of blacks and socioeconomic demographics that are similar to the United States in general. Both the GCNKSS and the current study were approved by the Institutional Review Boards at all participating hospitals. (For expanded paragraph, see online data supplement, available at http://stroke.ahajournals.org.)

Study nurses screened the medical records of all inpatients with primary or secondary stroke-related ICD-9 discharge diagnoses (430–436) from the 18 acute-care hospitals in the study region for the study period 1/1/99 to 12/31/99. We also ascertained strokes not found by ICD-9 codes by screening all visits to the hospitals’ ED (with the exception of Cincinnati Children’s Hospital) using hot-pursuit methodology.

To qualify as an incident case, a patient must have met the criteria for 1 of the 5 stroke categories adapted from the Classification for Cerebrovascular Diseases III and from epidemiological studies of stroke in Rochester, MN: cerebral ischemia, intracerebral hemorrhage, subarachnoid hemorrhage, stroke of uncertain cause, or transient ischemic attack (TIA). The onset of stroke symptoms must have occurred during the study period. In addition, for this analysis: (1) cases must have used EMS and resided at home, not including nursing, retirement, or group homes; (2) the stroke must have occurred at home (for geocoding purposes); and (3) the record must have a recorded EMS on-scene time and an ED arrival time. The use of EMS was defined as calling 911, not merely using an ambulance for transportation purposes.

Once potential cases were identified, a study nurse gathered information regarding stroke symptoms, physical examination findings, past medical/surgical history, vital signs and ED evaluation, neurological evaluation, diagnostic test results, treatments, and outcome. EMS times were collected during the initial chart abstraction by the study nurses. Generally, times were collected from the EMS run sheets (filled out by EMS providers during the time spent with the patient). Cases were excluded if their speed of transportation exceeded an average of 80 miles/hour. Classification of race/ethnicity was as self-reported in the medical administrative record. (For expanded paragraph, see online data supplement.)

For each individual stroke patient included in the analysis, the SES of the community in which they lived was estimated by aggregate measures of SES as published by the 2000 US Census Bureau website (www.census.gov). Previous studies have verified census tracts as a valid measure of socioeconomic status. There are 346 census tracts within the 5-county region of Greater Cincinnati/Northern Kentucky, ranging in character from rural to urban and from extremely deprived to extremely wealthy. (For expanded paragraph, see online data supplement.)

The census tract measure of SES that was used for this analysis was the percentage of the population below poverty, which has been...
used the most frequently and has been validated in prior studies.\textsuperscript{7,8} Once a patient’s community SES was estimated using the method described above, the SES measure was linked to the remaining clinical information for that stroke patient, so that a patient-level analysis could be performed. For the purposes of the analysis, 4 possible categories of percentage below poverty were designated: 0% to 5%, 5% to 10%, 10% to 25%, and >25%. The number of census tracts for each chosen category of percent below poverty in the region are as follows: 0% to 5%; 108; 5% to 10%; 103; 10% to 25%; 68; >25%; 66. In 2000, the defined poverty threshold for household income per year for a family of 4 was $17 603. In general, comparisons were made between patients residing in the poorest versus the richest communities. (For expanded paragraph, see online data supplement.)

When determining the effects of SES on transport time, we adjusted for the distance between a patient’s residence and the first medical center where they were treated. Distances were calculated in miles “as the crow flies,” because it was impossible to predict the exact path taken by EMS, the traffic patterns, weather conditions, etc. Determining distance effects on the dispatch time (time from 911 call to arrival on the scene) was not possible, because ambulances are not necessarily sent from their home base, and starting location when receiving a dispatch is assumed to not have used EMS for the purposes of this analysis. Patients who lived at home and had their stroke at home but did not use 911 (not included in the analysis described below) were of similar race and gender to those who called 911. However, patients who did not use 911 were more likely to be slightly younger (mean age 69 versus 73; \(P<0.0001\)) and were more likely to live in slightly richer areas (% below poverty 10.9% versus 12.5%; \(P=0.001\)) than those who called 911.

Figure 1 maps the locations of the homes of stroke patients within our population along with the locations of local ED. The socioeconomic distribution of the region, as demonstrated by the percentage of persons living below the poverty level, is also displayed in Figure 1. As shown, there is a broad range of SES in the region, ranging from extremely wealthy areas to areas with >70% living below poverty.

The various EMS prehospital time intervals are shown in Figure 3. Mean distance to hospital was 4.2 miles (SD 3.5 miles), with a maximum distance of 37.7 miles. The mean time from call to arrival on-scene was 6.5 minutes (median 5), mean time on-scene was 14.1 minutes (median 13), and mean transport time was 13.1 minutes (median 11). The mean time from arrival on-scene to hospital was 28.0 minutes (median 26), with a maximum time of 90 minutes.

The relationship between SES and prehospital time intervals is demonstrated in Table 2. Only variables that reached statistical significance, along with the SES variable “percent below poverty,” were included in the final model. Poorer

### Results

During the study period, 3814 stroke and TIA patients were hospitalized for their stroke. Of these, 38.8% of patients called 911, 37.2% presented directly to an ED without calling 911, 2.7% initially presented to another medical professional, such as their primary doctor, and 7.4% of strokes occurred while admitted to the hospital for another diagnosis. There were missing records of EMS use in 13.9%; these were assumed to not have used EMS for the purposes of this analysis. (For expanded paragraph, see online data supplement.)

After the inclusion criteria were applied for the socioeconomic analysis (see Figure 2 and online data supplement for description of excluded patients), there were 978 patients who lived at home and had their stroke at home, who had valid EMS times, and whose addresses were successfully geocoded. These patients were 56% female and 18% black, with a mean age of 73 years (SD 13 years; see Table 1 for a detailed description of the demographics of these stroke patients, stratified by their community SES). Stroke severity (as documented by initial examination in the ED) and stroke subtypes did not significantly differ among SES groups.

Patients who lived at home and had their stroke at home but did not use 911 (not included in the analysis described below) were of similar race and gender to those who called 911. However, patients who did not use 911 were more likely to be slightly younger (mean age 69 versus 73; \(P<0.0001\)) and were more likely to live in slightly richer areas (% below poverty 10.9% versus 12.5%; \(P=0.001\)) than those who called 911.

### Table 1. Demographics of Stroke and TIA Patients Who Used EMS, Lived at Home, and Had Their Stroke at Home, Greater Cincinnati/Northern Kentucky Region, 1999 (n=978)

<table>
<thead>
<tr>
<th>Community SES: % below poverty within the census tract of residence</th>
<th>&lt;5%</th>
<th>5% to &lt;10%</th>
<th>10% to &lt;25%</th>
<th>≥25%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean age (SD)</strong></td>
<td>74 y (12.6)</td>
<td>74 y (12.2)</td>
<td>73 y (13.1)</td>
<td>69 y (16.4)</td>
<td>73 (13.2)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>138</td>
<td>44.1%</td>
<td>142</td>
<td>47.2%</td>
<td>108</td>
</tr>
<tr>
<td>Female</td>
<td>175</td>
<td>55.9%</td>
<td>159</td>
<td>52.8%</td>
<td>131</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>10</td>
<td>3.2%</td>
<td>27</td>
<td>9.0%</td>
<td>53</td>
</tr>
<tr>
<td>White</td>
<td>303</td>
<td>96.8%</td>
<td>274</td>
<td>91.0%</td>
<td>186</td>
</tr>
<tr>
<td><strong>Median household income</strong></td>
<td>$60 377</td>
<td>$43 367</td>
<td>$32 281</td>
<td>$17 092</td>
<td>$42 744</td>
</tr>
</tbody>
</table>
community SES was associated with increased dispatch-to-arrival and transport EMS times and reduced EMS on-scene times. On average, it took slightly longer for EMS teams to reach stroke patients living in the poorest SES neighborhoods than in the richest. However, less time was spent on the scene in the poorer communities. Patients residing in the poorer communities had a slightly longer travel time to the hospital, with slower speeds, even when distance from the residence to hospital was considered. In fact, no patients living in areas with >25% poverty level were transported faster than an average of 40 mph.

Because of these differing associations with poverty, SES had no significant impact on the overall EMS time from initial 911 call to arrival at the hospital. In general, the absolute increase in times for any of the demographic factors considered was small: the largest difference was 5 minutes.

There was a longer transport time for blacks, independent of SES; there was no significant interaction between SES and race. Unlike the poorer communities, EMS was delayed in every time interval considered for blacks, and the overall effect of race was a statistically significant delay of ≈5.0 minutes ($P<0.001$) when compared with whites. Transport times also increased with advancing age of the patient, although the increase was small: ≈0.9 minutes per increasing decade. Finally, transportation time increased by 1.8 minutes for every mile farther away the patient resided from the destination hospital, as would be expected. There was no interaction between SES and distance to the local hospitals.

### TABLE 2. Comparisons of EMS Prehospital Times for Acute Stroke Patients by Demographic Variables

<table>
<thead>
<tr>
<th></th>
<th>Difference in Minutes</th>
<th>CIs</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatch time</td>
<td>1.34</td>
<td>0.09–2.60</td>
<td>0.036</td>
</tr>
<tr>
<td>% below poverty</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black vs white</td>
<td>1.40</td>
<td>0.13–2.93</td>
<td>0.07</td>
</tr>
<tr>
<td>% below poverty</td>
<td>−3.41</td>
<td>1.46–5.36</td>
<td>0.001</td>
</tr>
<tr>
<td>On-scene time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% below poverty</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black vs white</td>
<td>2.46</td>
<td>0.96–3.96</td>
<td>0.001</td>
</tr>
<tr>
<td>Age (per decade)</td>
<td>0.44</td>
<td>0.09–0.79</td>
<td>0.01</td>
</tr>
<tr>
<td>Distance per mile</td>
<td>1.52</td>
<td>1.39–1.65</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>% below poverty</td>
<td>4.22</td>
<td>2.29–6.15</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Transport time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% below poverty</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black vs white</td>
<td>5.04</td>
<td>2.65–7.43</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Distance</td>
<td>1.82</td>
<td>1.61–2.03</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age</td>
<td>0.90</td>
<td>0.34–1.46</td>
<td>0.002</td>
</tr>
<tr>
<td>% below poverty</td>
<td>2.57</td>
<td>−0.50–5.64</td>
<td>0.101</td>
</tr>
</tbody>
</table>

**Discussion**

Within our population, living in a poorer area does not appear to delay access to acute care for stroke in a clinically significant way. We did find small, statistically significant delays in prehospital times that were associated with poorer communities, black race, increasing age, and distance to the hospital. However, on average, the prehospital time spent with EMS was very short: the average time from 911 call to arrival at hospital for acute stroke patients in our population was only 28 minutes. The time needed to reach the patient after the 911 call, in particular, was outstanding, at an average of only 6.5 minutes. These time intervals are remarkably similar to previously published prehospital time intervals for both myocardial infarction and stroke.12–14

Interestingly, the various prehospital time intervals appear to be affected differently by poorer SES, albeit with very small differences. The time spent on-scene is significantly shorter in poorer than in richer areas, and yet the time needed to reach the patient, and the transport time, is longer in poorer areas. This longer transport time is not related to different distances to hospital between the lower and higher SES groups, because there was no interaction between SES and distance. Traffic is more congested in the downtown, poorer communities, and this may be a partial explanation. Another possibility could be that overcrowded urban EDs may have EMS wait in cue to off-load patients, thus increasing the transportation times. The shorter on-scene times in the poorer areas may reflect differences in efficiency, experience, or attitude of the EMS systems: in our downtown area, for example, the EMS services maintain a very high volume of runs, and perhaps because of that, they may be driven to act more quickly on-scene. Any analysis of prehospital times...
should include an analysis of these individual time intervals, such as the on-scene times and transport times, as the individual intervals essentially cancel out some of the overall effects.

These observed differences in EMS time intervals between demographic groups are relatively small, and they are most likely not clinically significant. Nevertheless, the study of the influences of demographic factors on these times is still important, because it may belie larger issues that affect overall access care for these patients, and it can be used to direct future interventions. For example, the time EMS spent on-scene was on average of 14 minutes, but many patients had times much longer than that. This time interval may be the most logical target for EMS-based interventions regarding stroke awareness to decrease prehospital EMS related delays.

Within our population, only 38% of stroke and TIA patients used EMS, despite numerous public awareness campaigns. This is consistent with a prior population-based report from eastern Texas, which also reported 38% EMS use in validated stroke patients. Other non–population-based reports of EMS have reported higher rates of EMS use, but these registry-based studies could suffer from referral bias which may explain the reported higher rates of EMS use, and can be used to direct future interventions. For example, the time EMS spent on-scene was on average of 14 minutes, but many patients had times much longer than that. This time interval may be the most logical target for EMS-based interventions regarding stroke awareness to decrease prehospital EMS related delays.

Public education efforts should not only focus on stroke warning signs, but they must also include the idea that patients should call 911 right away once these symptoms occur. One might hypothesize that a patient’s SES, particularly their educational level, might have a much larger impact on the time interval between symptom onset and the 911 call. The additive effects of SES on both the EMS times and time from symptom onset to the 911 call may result in clinically significant delays in treatment. This analysis is planned in the near future.

The largest limitation of our analysis is that these results are only applicable to stroke patients that are living at home and have their strokes at home. We were unable to include patients whose strokes occurred in locations other than their home, because the actual address of the location of stroke occurrence was never documented in the medical record. We note that only 17% of strokes occurred at places other than home (workplace and in-hospital were the 2 most common other locations). We also did not include strokes in persons who did not live at home, most notably those living in nursing homes (n=372) because EMS response to such an institution would be inherently different than that to a residence. For example, EMS may consider a stroke at a nursing home to be under medical care; therefore, they might not respond as quickly. We were unable to analyze the speed of response to the 911 call, because location of ambulances at the time of dispatch is not recorded. Another important limitation is the complexity of the possible explanations for our findings, especially on a population-wide basis. Because of the nature of our retrospective analysis, we are unable to sort out all of the possible interactions with prehospital times for stroke patients, such as traffic patterns, speed limits, time of day, and civil engineering, among others. In fact, distances between the stroke patient’s house and the hospital were calculated “as the crow flies” because we were unable to reliably predict the route of travel. However, because no meaningful differences could be found between SES and transport times, this at least suggests care is similar between those with a high and those with a low SES. Further prospective study, designed to separate out the various implicated factors inprehospital times, would be necessary to confirm our findings that times for EMS transport of stroke patients are independent of the patients’ SES.

Other limitations include the limitations of a retrospective review, and the documentation of times in the medical record. However, we were able to obtain the required times in 91% of patients who lived at home and had their stroke at home. It is unknown whether the remaining 9% of stroke patients’ times were truly unknown or just weren’t documented, and the exclusion of patients with unknown times may potentially bias our results. In addition, the use of community SES as an estimate of socioeconomic status in general is not always perfect: one could imagine a much higher income patient living in a poorer neighborhood, or vice versa. However, the use of community SES for such purposes has been validated in the literature,6,20,21 and community SES may have unique contributions, especially regarding access to medical care, that may be less dependent on individual SES (eg, traffic patterns, crime, etc). Previous publications have also suggested important racial differences in the importance of community effects.21 Finally, these results are only applicable to relatively densely populated urban environments. Whereas some of our patients lived in rural areas, the majority of patients lived very close to a nearby hospital (average of 4 miles). Rural environments with sparsely populated areas and volunteer EMS units may need to focus more on the dispatch to arrival time intervals, instead of other time periods.

Although the authors believe that it is extremely important to minimize delays within the EMS system, we would like to emphasize that the delay related to patient or family recognition of stroke symptoms, and limited use of 911 services, are likely much more important, on average, than delays that occur because of EMS systems and providers. This has recently been confirmed by the California Paul Coverdell registry, which found that increasing early recognition of symptoms for ischemic stroke patients would hypothetically increase thrombolytic treatment by orders of magnitude more than other interventions, including the presence of stroke teams, “instantaneous EMS responses” and prompt medical evaluation.22 Public awareness of stroke remains poor,23–25 and further research is needed regarding strategies to improve public knowledge and behavior if we are ever to increase the acute treatment of stroke patients.

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References


Community Socioeconomic Status and Prehospital Times in Acute Stroke and Transient Ischemic Attack. Do Poorer Patients Have Longer Delays From 911 Call to the Emergency Department?

Dawn O. Kleindorfer, Christopher J. Lindsell, Joseph P. Broderick, Matthew L. Flaherty, Daniel Woo, Irene Ewing, Pam Schmit, Charles Moomaw, Kathleen Alwell, Arthur Pancioli, Edward Jauch, Jane Khoury, Rosie Miller, Alexander Schneider and Brett M. Kissela

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