Door-to-Door Capture of Incident and Prevalent Stroke Cases in Durango, Mexico
The Brain Attack Surveillance in Durango Study

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Background and Purpose—Stroke incidence and prevalence estimates in developing countries should include stroke cases not presenting to hospital. We performed door-to-door stroke case ascertainment in Durango Municipality, Mexico, to estimate stroke incidence and prevalence and to determine the error made by only ascertaining hospital cases.

Methods—Between September 2008 and March 2009, 1996 housing units were randomly sampled to screen for stroke in Durango Municipality residents 35 years of age and older. Field workers utilized a validated screening tool. Those screening positive were referred to a neurologist for history and examination and a head CT scan. Prevalence and cumulative incidence from the door-to-door surveillance were calculated and compared with previously reported hospitalization rates during the same defined time.

Results—Respondents included 2437 subjects from 1419 homes. The refusal rate was 3.8%. Twenty subjects had verified or probable stroke. The prevalence of probable or verified stroke was 7.7 per 1000 (95% CI, 4.3 per 1000–11.2 per 1000). Five patients had a stroke during the time of the hospital surveillance, yielding a cumulative incidence of 232.3 per 100 000 (95% CI, 27.8–436.9). Two of the 5 cases were captured by door-to-door surveillance but not by hospital surveillance.

Conclusions—This study provides the first community-based stroke prevalence and incidence estimates in Mexico. The wide confidence intervals, despite the large number of surveyed housing units, suggest the need for more advanced sampling strategies for stroke surveillance in the developing world. (Stroke. 2011;42:00-00.)

Key Words: epidemiology ■ stroke ■ surveillance

Because stroke has become a major health problem for many Latin American countries, the widely recognized paucity of good-quality stroke epidemiology data from these countries is a major impediment to stroke reduction. Development and maintenance of a stroke surveillance system are essential to estimate the burden of stroke in communities and to monitor the success of interventions. The Brain Attack Surveillance in Durango (BASID) project was established to build the vital infrastructure necessary for a surveillance system for stroke in a representative Mexican community. BASID emerged from an international collaboration to study stroke epidemiology in a similar fashion as the Brain Attack Surveillance in Corpus Christi (BASIC) study in Texas.2 Recently, BASID reported the crude annual stroke hospitalization rate for those aged 25 and older as 143 per 100 000 (95% CI, 128–158).3 However, hospital surveillance alone is usually inadequate to identify all stroke cases because not all patients present to a hospital,4 perhaps because of mild stroke severity and expense of hospitalization. Instead, multiple sources of case ascertainment are often used in population-based studies to identify stroke patients outside hospitals, as outlined by the World Health Organization in its STEPS project.5 Door-to-door surveillance may be the only way to determine the proportion of subjects missed by limiting surveillance in Durango Municipality to hospitals and their emergency departments. We therefore performed a study of randomly selected households to estimate stroke incidence and prevalence, and to determine the proportion of cases missed by hospital surveillance only.

Subjects and Methods
BASID took place in Durango Municipality, which is located in northern Mexico and encompasses 1 large city, Durango City, and 112 small towns and villages. The total population was 527 157 in 2005 (target population aged 35 years and older: 168 859), with ~90% of the population residing within Durango City, the capital of

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Durango. The door-to-door surveillance was performed from September 2008 to March 2009.

In stage 1, Durango Municipality households were randomly sampled to find household members who screened positive for stroke or stroke symptoms. During stage 2, participants who screened positive in stage 1 were invited to have an evaluation by a neurologist (A.R.) to verify a clinical diagnosis of stroke and were offered a head CT if not previously performed.

Inclusion criteria were that subjects were aged 35 years or older and had resided in Durango Municipality during the preceding 6 months. If a person normally residing in the house in Durango City and surrounding suburban towns was absent during the survey, then 5 more attempts to contact that person were made, either the same day or on a subsequent day. Because of the difficulty in traveling to rural towns, only 1 in-person contact attempt was made to find the subjects residing in those areas. If a family member stated the subject was available by telephone, then telephone contact was attempted on a subsequent day. If 2 telephone contact attempts were unfruitful, then a proxy interview was allowed. The relationship of the person providing the proxy for the subject was noted. If no proxy was available, then absent subjects were coded as nonresponders.

Field Workers Approach to Residents
Five field workers received training in the use of the survey questionnaires. Address, age, and gender were noted for residents who declined participation. In residents who agreed to participate, a brief cognitive screen was performed to ensure they had the cognitive ability to answer for themselves; 3 survey questionnaires were then administered. The first gathered demographic and baseline community stroke risk factors. The second ascertained history of possible fatal stroke in others in the household during the time of the survey. The third questionnaire was designed to determine stroke-free status in the respondent. We used a validated Spanish translation of a modified version of the World Health Organization instrument for assessment of stroke prevalence in developing countries. This instrument consists of 8 questions aimed at identifying whether the individual has ever experienced a sudden focal neurological deficit that lasted >24 hours.

Anyone who answered “yes” to ≥1 of the 8 questions was considered positive for suspected stroke and invited to participate in the second part of the study. These subjects were invited to attend an outpatient clinic at the General Hospital of Durango City, where a neurologist performed a medical history and neurological examination. The diagnosis of stroke was established using the definition of the World Health Organization as patients with a rapid onset of a clinical neurological deficit lasting >24 hours without a competing, plausible, nonvascular cause. Definite stroke was defined as meeting the World Health Organization definition and having confirmation by imaging. Probable stroke was defined as meeting the World Health Organization definition but with no imaging performed or imaging performed but unavailable for review. Medical history was focused on presence of vascular risk factors, symptoms, and medical record review from the time of the event. A structured neurological examination focused on eliciting focal neurological deficits utilizing a validated Spanish version of the National Institute of Health Stroke Scale. A nonenhanced head CT scan was performed to confirm stroke and to classify stroke type.

Sampling Framework
Selection of housing units was conducted in a stratified multistage design. Durango Municipality was divided into 2 strata: Durango City and all other localities in the Municipality. From each stratum, basic geostatistical areas (similar to census tracts) were sampled at random proportional to size (size was the number of housing units in the basic geostatistical areas). Street blocks within basic geostatistical areas were randomly selected and, finally, housing units within street blocks were chosen using systematic sampling. The total number of housing units selected from each stratum was approximately proportional to the number of housing units in each stratum. Table 1 shows the strata, the number of housing units per strata, and the final number of housing units selected from each.

### Table 1. Survey Strata for Durango Municipality

<table>
<thead>
<tr>
<th>Strata</th>
<th>Total N of Housing Units by Strata (%) in Municipality</th>
<th>N Housing Units Selected for Survey by Strata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>112 809 (88.8)</td>
<td>1657</td>
</tr>
<tr>
<td>Other</td>
<td>14 243 (11.2)</td>
<td>339</td>
</tr>
<tr>
<td>Total</td>
<td>127 052</td>
<td>1996</td>
</tr>
</tbody>
</table>

Statistical Analysis
Descriptive statistics for all variables collected were calculated. Stroke prevalence was defined as any history of stroke. Cumulative stroke incidence was defined as new stroke occurring between August 2007 and July 2008. Cumulative stroke incidence was calculated as the number of cases divided by the number of people at risk based on 2005 census data. However, given the multistage sampling design and nonresponse rate, the cumulative stroke incidence, prevalence rate, and their 95% CI were calculated by constructing a weighted average of the cumulative stroke incidence and prevalence rates in strata using survey weights. Survey weights were constructed using standard formulas and were based on location (urban vs rural), age, and gender and were adjusted for nonresponse.

For the purpose of constructing survey weights, age was categorized into 6 levels of 10-year intervals: 35 to 44, 45 to 54, 55 to 64, 65 to 74, 75 to 84, and 85 and older. To adjust the survey weights for the nonresponse rate, we used the number of eligible people in responding households to estimate the average number of eligible people in nonresponding households. Cumulative incidence was reported as cases per 100 000 and prevalence was reported as cases per 1000. All calculations were performed using SAS version 9.2.

Ethics
The BASID project was approved by the Institutional Review Board of the University of Michigan and the National Institute of Medical Sciences and Nutrition Salvador Zubiran in Mexico, as well as the 3 public hospitals in Durango Municipality. All study personnel completed U.S. National Institutes of Health Human Subjects Protection Training, translated to Spanish. Two separate consent processes were used for the door-to-door survey. In stage 1, the stroke questionnaire survey, oral consent was obtained and an informational study handout was given to eligible participants that summarized information about the study. For participants who screened positive in stage 1, written consent was obtained to participate in stage 2.

Results
A total of 1996 housing units were screened by study personnel (Table 1). We excluded 577 homes (28.9%) for ≥1 of the following reasons: 380 homes (65.9%) because residents were younger than 35 years old; 136 (23.6%) homes were uninhabited; 30 (5.2%) because residents lived in Durango Municipality <6 months; 25 (4.3%) because residents were out of home during screening in remote.
areas and we were unable to contact them later; and 22 (3.8%) homes with people who refused to participate. Of the remaining 1419 homes (71.1%), ≥1 eligible residents participated in the survey interview; 1189 (83.8%) were from urban areas and 230 (16.2%) were from nonurban localities.

A total of 2437 surveys were obtained (2049 from urban areas and 388 from nonurban localities). The majority of the sample was women (56.7%), and the sample had a mean age of 51.5 years. The Figure shows the flow chart of the eligible population and stroke status. Thirty residents screened positive for possible stroke; 10 subjects were found not to have had a stroke after neurological evaluation and head CT scan. The other 20 met clinical criteria for stroke. In 13 of the 20, neurological examination and head CT verified stroke. Of the 7 remaining subjects, in 3 the stroke was suspected based on neurological history and examination but final validation was not possible because the patients did not attend the head CT appointment; in 4 subjects, we were unable to verify stroke because they refused to participate in the second part of the study (2 lived too far away and 2 found travel too difficult because of advanced age or severe disability). These final 7 subjects were classified as having probable stroke.

The prevalence of probable or verified stroke was 7.7 per 1000 (95% CI, 4.3 per 1000–11.2 per 1000); for only verified stroke, it was 5.1 per 1000 (95% CI, 2.3 per 1000–7.9 per 1000). The small number of stroke cases precludes a further classification into stroke types. Demographics and stroke risk factors of participants are shown in Table 2 by stroke status and gender. Table 3 compares the cumulative stroke incidence and in-hospital case fatality rates obtained during the hospital surveillance period with that of the door-to-door survey. Because 5 patients with a stroke were identified in the door-to-door survey (2 who survived and 3 who died) during the hospital surveillance period (August 2007–July 2008), the cumulative incidence obtained from door-to-door surveillance was 232.3 per 100 000 (95% CI, 27.8–436.9). When standardized to the World Health Organization population, the cumulative incidence was 270.7 per 100 000 (95% CI, 33.6–507.9). This compares with the rate obtained in the same population from hospital-only surveillance in which the

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**Table 2. Demographics and Stroke Risk Factors of All Respondents to Door-to-Door Survey**

<table>
<thead>
<tr>
<th></th>
<th>Eligible Population</th>
<th>Screened Negative for Possible Stroke</th>
<th>Screened Positive for Possible Stroke</th>
<th>Verified Stroke</th>
<th>Probable Stroke</th>
<th>Not a Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>2437</td>
<td>2407</td>
<td>30</td>
<td>13</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Age, mean (SD)</td>
<td>51.5 (12.6)</td>
<td>51.4 (12.6)</td>
<td>59.0 (12.9)</td>
<td>64.0 (14.2)</td>
<td>58.7 (6.9)</td>
<td>52.8 (12.5)</td>
</tr>
<tr>
<td>Female</td>
<td>56.7% (1381)</td>
<td>56.5% (1361)</td>
<td>66.7% (20)</td>
<td>53.9% (7)</td>
<td>57.1% (4)</td>
<td>90.0% (9)</td>
</tr>
<tr>
<td>Needed proxy</td>
<td>1.1% (26)</td>
<td>0.9% (21)</td>
<td>16.7% (5)</td>
<td>30.8% (4)</td>
<td>14.3% (1)</td>
<td>0.0% (0)</td>
</tr>
<tr>
<td>Own telephone</td>
<td>89.9% (2190)</td>
<td>89.8% (2162)</td>
<td>93.3% (28)</td>
<td>100% (13)</td>
<td>71.4% (5)</td>
<td>100% (10)</td>
</tr>
<tr>
<td>Heart disease</td>
<td>5.3% (125)</td>
<td>5.0% (121)</td>
<td>23.3% (7)</td>
<td>23.1% (3)</td>
<td>0.0% (0)</td>
<td>40.0% (4)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>29.1% (708)</td>
<td>28.6% (688)</td>
<td>66.7% (20)</td>
<td>46.2% (6)</td>
<td>85.7% (6)</td>
<td>80.0% (8)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>14.5% (353)</td>
<td>14.2% (341)</td>
<td>40.0% (12)</td>
<td>46.2% (6)</td>
<td>57.1% (4)</td>
<td>20.0% (2)</td>
</tr>
<tr>
<td>Current smoker</td>
<td>20.5% (500)</td>
<td>20.5% (494)</td>
<td>20.0% (6)</td>
<td>15.4% (2)</td>
<td>42.8% (3)</td>
<td>10.0% (1)</td>
</tr>
<tr>
<td>Seen physician in past year</td>
<td>76.1% (1854)</td>
<td>75.8% (1825)</td>
<td>96.7% (29)</td>
<td>92.3% (12)</td>
<td>100% (7)</td>
<td>100% (10)</td>
</tr>
<tr>
<td>Lived/worked in United States</td>
<td>14.8% (361)</td>
<td>14.8% (356)</td>
<td>16.7% (5)</td>
<td>23.1% (3)</td>
<td>28.6% (2)</td>
<td>0.0% (0)</td>
</tr>
</tbody>
</table>
stroke rate was 178.3 per 100,000 (95% CI, 159.2–199.6), and when standardized to the World Health Organization population the stroke rate was 208.5 per 100,000 (95% CI, 184.9–232.2).

Of the 2 stroke cases missed during hospital surveillance, 1 was an 89-year-old woman who received medical care in an outpatient clinic only. The other patient was a 70-year-old woman who had a stroke outside Durango Municipality and was discharged to her Durango Municipality home, where she died 3 months later from medical complications associated with severe stroke disability.

Finally, by restricting the analysis to those aged 45 years or older, we were able to compare the annual cumulative stroke incidence in non-Hispanic whites and Mexican Americans in Corpus Christi, Texas (BASIC study),2 with Mexicans in Durango Municipality. Of the 1558 people aged 45 years or older surveyed in Durango Municipality, 5 had verified stroke during the survey period, giving a cumulative incidence of 386 per 100,000 compared with the cumulative stroke incidence for U.S. Mexican Americans (560/100,000) and non-Hispanic whites (453/100,000).

Discussion
This extension of the BASID project utilizing the epidemiology “gold standard” of door-to-door surveillance suggests that cases are truly missed using ascertainment strategies that focus only on hospitals in Mexico. However, despite the labor-intensiveness of a door-to-door approach to 2437 subjects, stroke is rare enough to leave wide CI on estimates of incidence and prevalence. For more precise estimates, a much larger sample size with prohibitive expense and time would be needed. For example, using random sampling in the case of Durango Municipality, which has a target population of 168,859 and a point estimate of stroke incidence of 232 per 100,000, a sample size of 20,000 would be needed to obtain a margin of error of ±24 per 100,000, or 10%. However, there are additional and more sophisticated sampling techniques that could have been used to achieve smaller margins of errors without necessarily increasing costs.

One sampling technique that could increase the precision is to initially perform a screening phase to identify the location of residents at high-risk for stroke, for example, by focusing on the elderly. Once high-risk areas are identified, they are oversampled in comparison to low-risk areas (eg, neighborhoods with younger residents), a framework known as disproportionate sampling.12 Higher precision is gained by focusing efforts on the subpopulations in which more cases are likely to be found. In the BASID door-to-door surveillance, only 6% of our sample was aged 75 years or older and only 16% were aged 65 years or older.

Other screening methods can be used to capture more strokes. The most cost-effective is telephone interviews. However, they may bias toward patients with higher socioeconomic status (who are likely already captured in hospital based-surveillance) and toward urban residents (in Durango Municipality, 70% of the rural population have telephones compared to 94% of those in urban homes). Mailing surveys is another approach but could lead to a lower response rate and underestimation of cases, particularly in populations with limited mail services (eg, rural areas in developing countries). Another possibility would be to simply include neighboring houses if the target house was unoccupied at the time of the visit.

Another screening technique is network sampling, which works under the assumption that members of the stroke population know each other. In this framework, surveyors ask an identified member of the affected population (ie, a stroke survivor) to identify other affected members. For example, those who have experienced stroke may know other stroke victims through stroke support groups or by knowledge of relatives and friends. This reduces the number of contacts necessary by obtaining information on multiple subjects from 1 case. Alternatively, the cases identified by the first case may be contacted and, again, asked to identify more cases. When this process is iterated, that is, each subject with stroke found is asked to identify more who have had stroke until no more subjects are identified, the technique is called snowballing. Although it is more difficult to identify isolated cases using network sampling and snowballing,13 statistical approaches can be used to obtain an estimate of the missed cases by evaluating the overlap cases (those cases identified multiple times).12 Multiple sampling techniques can be used in combination to compensate for their individual limitations, although combining methods may require complex computational analysis to obtain correct standard errors.

The proportion of stroke patients admitted to hospitals reported in recent population-based studies in developing countries is variable, ranging from 66% in Georgia14 to as high as 95% in Brazil.15 The cumulative stroke incidence of 232.3 per 100,000 found in the current study is similar to that reported in recent population-based studies in developing countries, with the notable exception of Iran16 and Georgia.14

Table 3. Comparison of Cumulative Stroke Incidence From August 2007 to July 2008 Between Hospital Surveillance and Door-to-Door Survey

<table>
<thead>
<tr>
<th>Hospital Surveillance Study (95% CI)</th>
<th>Door-to-door survey (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strokes, n (incidence)</td>
<td>Surveyed population aged 35 y or older, n</td>
</tr>
<tr>
<td></td>
<td>178.3 (159.2–199.6)/100 000</td>
</tr>
<tr>
<td>Strokes missed by hospital surveillance phase, n</td>
<td>5</td>
</tr>
<tr>
<td>Strokes occurring outside of Durango, n</td>
<td>2</td>
</tr>
<tr>
<td>In-hospital stroke case fatality rate, n (%)</td>
<td>2</td>
</tr>
</tbody>
</table>

At-risk population aged 35 years or older: 168,859.

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Other screening methods can be used to capture more strokes. The most cost-effective is telephone interviews. However, they may bias toward patients with higher socioeconomic status (who are likely already captured in hospital based-surveillance) and toward urban residents (in Durango Municipality, ≈70% of the rural population have telephones compared to 94% of those in urban homes). Mailing surveys is another approach but could lead to a lower response rate and underestimation of cases, particularly in populations with limited mail services (eg, rural areas in developing countries). Another possibility would be to simply include neighboring houses if the target house was unoccupied at the time of the visit.

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which report the highest incidences of stroke in developing countries.

Although the BASID cumulative stroke incidence in Mexico is consistent with most developing countries, Mexican Americans living in the United States have a higher cumulative stroke incidence compared with Mexicans living in Durango Municipality. One possibility to explain the discrepancy between stroke incidence rates in Durango Municipality and in Corpus Christi is attributable to environmental or lifestyle changes that alter stroke susceptibility, as occurred in Japanese immigrants to the United States. An important focus of future work in both Durango Municipality and Corpus Christi will be to explore the social, environmental, biological, and genetic reasons for the discrepant stroke incidence in Mexicans on both sides of the border.

The stroke prevalence rate of 5.1 to 7.7 per 1000 in the community of Durango Municipality is within the range found in other door-to-door surveys in Latin America (Table 4). Other studies have used different definitions and age groups, making comparisons difficult. Prevalence rates are also comparable to those in European population-based studies, in which the range of crude stroke prevalence was 5 to 10 per 1000.

**Conclusion**

In summary, this work provides the first population-based study of stroke incidence and prevalence in Mexico comparing both hospital and door-to-door surveillance. Stroke cases that do not present to hospital are important in developing countries. More advanced sampling techniques are needed to maximize efficiency of community surveillance methods.

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**Disclosure**

None.

**References**


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