Worldwide, stroke is the second most common cause of mortality and the third most common cause of disability. The absolute number of people with stroke and the global burden of stroke-related disability are high and rising. Several studies have demonstrated ethnic variability in stroke mortality in Europe, but data on ethnic differences in stroke incidence are limited. The few studies that have assessed ethnic differences in the distribution of stroke subtypes in Europe were primarily based on the United Kingdom populations of African and South-Asian descent. These studies have shown large differences, both within and across ethnic groups. In the South London Ethnicity and Stroke study, intracerebral hemorrhage (ICH) was over 2-fold more common in the black African than in African Caribbean patients even after adjusting for risk factors and social class. Gaining insight into the incidence of stroke subtypes among different ethnic and migrant groups could help target prevention efforts. These findings underscore the need to identify the root causes of these ethnic differences to assist primary and secondary prevention efforts.

**Background and Purpose**—Data on the incidence of stroke subtypes among ethnic minority groups are limited. We assessed ethnic differences in the incidence of stroke subtypes in the Netherlands.

**Methods**—A Dutch nationwide register–based cohort study (n=7423174) was conducted between 1998 and 2010. We studied the following stroke subtypes: ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage. Cox proportional hazard models were used to estimate incidence differences between first-generation ethnic minorities and the Dutch majority population (ethnic Dutch).

**Results**—Compared with ethnic Dutch, Surinamese men and women had higher incidence rates of all stroke subtypes combined (adjusted hazard ratios, 1.43; 95% confidence interval, 1.35–1.50 and 1.34; 1.28–1.41), ischemic stroke (1.68; 1.57–1.81 and 1.57; 1.46–1.68), intracerebral hemorrhage (2.08; 1.82–2.39 and 1.74; 1.50–2.00), and subarachnoid hemorrhage (1.25; 0.92–1.69 and 1.26; 1.04–1.54). By contrast, Moroccan men and women had lower incidence rates of all stroke subtypes combined (0.42; 0.36–0.48 and 0.37; 0.30–0.46), ischemic stroke (0.35; 0.27–0.45 and 0.34; 0.24–0.49), intracerebral hemorrhage (0.61; 0.41–0.92 and 0.32; 0.16–0.72), and subarachnoid hemorrhage (0.42; 0.20–0.88 and 0.34; 0.17–0.68) compared with ethnic Dutch counterparts. The results varied by stroke subtype and sex for the other minority groups. For example, Turkish women had a reduced incidence of subarachnoid hemorrhage, whereas Turkish men had an increased incidence of ischemic stroke and intracerebral hemorrhage compared with ethnic Dutch.

**Conclusions**—Our findings suggest that Surinamese have an increased risk, whereas Moroccans have a reduced risk for all the various stroke subtypes. Among other ethnic minorities, the risk seems to depend on the stroke subtype and sex. These findings underscore the need to identify the root causes of these ethnic differences to assist primary and secondary prevention efforts. ([Stroke. 2014;45:3236-3242.](http://stroke.ahajournals.org/cgi/content/abstract/45/16/3236))

**Key Words:** ethnicity ■ intracerebral hemorrhage ■ minority groups ■ minority health ■ Netherlands ■ stroke ■ subarachnoid hemorrhage
Methods

Follow-Up Data Source

Data were obtained from the following Dutch national registers: Population Register, Hospital Discharge Register, Cause of Death Register, and Regional Income Survey. The registers were used to acquire information on demographic factors, stroke subtype hospitalizations and comorbidities, fatal stroke events, and income. The registers have been described in detail elsewhere. The reliability of Dutch national registers for stroke has been proven to be high. By linking these registers with a personal identifier, we built a cohort starting at January 1, 1998, when 15,431,715 Dutch citizens were registered in the Population Register. As only Population Register unique persons can be identified in the Hospital Discharge Register (unique with respect to the combination of the variables date of birth, sex, and 4 digits of the postal code), nonunique persons were excluded. This left a cohort of 13,421,681 (87.0%) persons. Because a low number of stroke events are expected in the young, persons <30 years of age were excluded (n=5,236,434 [39.0%]).

Persons were followed from January 1, 1998, until their first stroke event. We studied the following stroke subtypes: ischemic stroke (IS), ICH, and subarachnoid hemorrhage (SAH). A first event comprised a hospital admission with a primary or secondary diagnosis of SAH (International Classification of Diseases-9th Revision [ICD-9] code 430), ICH (ICD-9 code 431), or IS (ICD-9 code 434 and 436) or a fatal event with a primary or secondary cause of death of IS (ICD-10th Revision [ICD-10] code I63), ICH (ICD-10 code I61), or SAH (ICD-10 code I60). The positive predictive values of these codes have previously shown to be acceptable; ≥75% for ICD-9 code 430, ≥85% for ICD-9 code 431, ≥85% for ICD-9 codes 434 and 436. Persons who already had a previous hospital admission for a stroke between 1995 and 1997 were not included as having a first stroke. Persons were censored in case of death, emigration, or the end of the study period (December 31, 2010), whichever came first.

Determinants

Minority Groups

Ethnic minority groups were constructed based on the country of birth of the resident and his/her parents, according to the definition of Statistics Netherlands. A person is considered a minority if he/she was born abroad with ≥1 of the parents born abroad (first generation minority) or if he/she was born in the Netherlands with ≥1 of the parents born abroad (second generation minority). A person was identified as ethnic Dutch if both parents were born in the Netherlands. To investigate a homogeneous group, we included only first generation ethnic minority groups. The data on the second generation ethnic groups were excluded because of small numbers. The final cohort comprised 7,423,174 persons (Figure 1). For this study, ethnic Dutch (n=7,045,374) and ethnic minorities originating from Suriname (n=102,462), Morocco (n=39,714), Turkey (n=78,616), the Netherlands Antilles (n=27,033), Indonesia (n=120,577), and China (n=9398) were included. The other ethnic minority groups were excluded because of small numbers (ie, n<1000). Migration histories of these populations have been discussed in details elsewhere.

Explanatory Variables

Socioeconomic Status

Socioeconomic status was based on income data registered in the Regional Income Survey. The Regional Income Survey started in 1994 when a representative sample of 1.9 million Dutch citizens was selected. Every year, the sample was corrected for emigration and mortality, on the one hand, and immigration and birth, on the other hand. All persons belonging to the households of the sample population (about one third of the Dutch population) were included in the Regional Income Survey. To be able to correct for socioeconomic status in all study participants, socioeconomic status was based on the area income in the year before baseline. In each neighborhood, the mean disposable income of all residents with income data available was calculated for 1997 and subsequently assigned to all residents living in that neighborhood on January 1, 1997. Area income was divided into tertiles, with the first tertile representing the lowest income group.

Comorbidity

Presence and extent of comorbidity were determined with the Charlson Index Score based on discharge diagnosis within 3 years before baseline (1995–1997). The Charlson Index Score ranges from 0 to 6 (cut-off value), with 0 representing no comorbidity. This score was subsequently divided into 4 categories (0, 1–2, 3–4, and ≥5). The Charlson Index Score had been proven to be a reliable and valid method for measuring comorbidity in clinical research.

Figure 1. Flow chart.
Data Analysis
Baseline characteristics were analyzed at January 1, 1998. Incidence rates of stroke subtypes stratified by ethnic group and sex were calculated as the number of events per 100,000 person-years at risk and subsequently age-standardized to the age distribution of the European standard population (using the direct method) with 10-year age bands. For the calculation of incidence differences in stroke subtypes between minority groups and the ethnic Dutch (reference), Cox proportional hazard regression analyses were used. Analyses were stratified by sex because of interaction with ethnicity. To adjust for potential confounders, analyses were corrected for age at baseline, marital status, area income, degree of urbanization, and Charlson index. Results were expressed as hazard ratios with accompanying 95% confidence intervals. We used SPSS software, version 14.0 (SPSS Inc, Chicago, IL). All analyses were performed in accordance with privacy legislation Netherlands.

Results
Baseline Characteristics
Table 1 shows the characteristics of the study population. In general, the ethnic minority groups were younger (except for Indonesian), more concentrated in low income urban areas, and had less comorbidities than the ethnic Dutch people. Turks and Moroccans were the most, and Antilleans and Surinamese were the least likely to be married or living with a partner.

Combined Stroke Types
The absolute number of events and the age-standardized incidence of the various stroke subtypes by sex are shown in Table 2. When all the various stroke subtypes were combined, among men, Surinamese, Antillean, and Indonesian men had a higher incidence, whereas Moroccan and Chinese men had a lower incidence compared with ethnic Dutch men (Figure 2A). Similar findings were observed among women, with Surinamese and Indonesian women having a higher incidence, whereas Moroccan and Chinese women having a lower incidence compared with ethnic Dutch (Figure 2B). There were no differences between Antillean, Turkish, and ethnic Dutch women.

Ischemic Stroke
Among men, Surinamese, Turks, and Indonesians had a higher incidence of IS, whereas Moroccans and Chinese had a lower incidence of IS compared with ethnic Dutch men (Figure 2A). Antillean men also had a higher incidence than ethnic Dutch, though the difference was nonstatistically significant. Among women, the incidence of IS was higher in Surinamese and Indonesians, but lower in Moroccans than in ethnic Dutch women (Figure 2B). No significant differences were observed between the other ethnic minority groups and ethnic Dutch.

Intracerebral Hemorrhage
Among men, the incidence of ICH was higher in all ethnic minority groups than in ethnic Dutch men ranging from hazard ratio=1.48 (95% confidence interval, 1.23–1.77) in Antilleans to hazard ratio=2.29 (95% confidence interval, 1.60–3.28) in Chinese except for the lower incidence in Moroccans (Figure 2A). Among women, Surinamese, Indonesian, and Chinese had a higher incidence of ICH than ethnic Dutch women, whereas Moroccan women had a lower incidence of ICH than ethnic Dutch women (Figure 2B). There were

### Table 1. Baseline Population Characteristics of the Dutch Majority Population and First Generation Ethnic Minority Groups

<table>
<thead>
<tr>
<th>Ethnic-Dutch</th>
<th>Surinamese</th>
<th>Moroccan</th>
<th>Turk</th>
<th>Antillean</th>
<th>Indonesian</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>7045374</td>
<td>102462</td>
<td>39714</td>
<td>78616</td>
<td>27033</td>
<td>120577</td>
</tr>
<tr>
<td>Men (%)</td>
<td>48.2</td>
<td>45.7</td>
<td>58.0</td>
<td>55.5</td>
<td>47.3</td>
<td>45.4</td>
</tr>
<tr>
<td>Median age (IQR)</td>
<td>50 (40–64)</td>
<td>42 (36–52)</td>
<td>39 (33–49)</td>
<td>40 (34–52)</td>
<td>42 (36–50)</td>
<td>57 (47–69)</td>
</tr>
<tr>
<td>Married or living together (%)</td>
<td>69.2</td>
<td>41.8</td>
<td>80.4</td>
<td>85.3</td>
<td>38.0</td>
<td>59.6</td>
</tr>
<tr>
<td>Socioeconomic status based on a real income (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tertile 1</td>
<td>29.3</td>
<td>63.5</td>
<td>62.6</td>
<td>72.5</td>
<td>56.9</td>
<td>33.8</td>
</tr>
<tr>
<td>Tertile 2</td>
<td>34.5</td>
<td>18.7</td>
<td>23.0</td>
<td>19.5</td>
<td>23.1</td>
<td>30.0</td>
</tr>
<tr>
<td>Tertile 3</td>
<td>36.2</td>
<td>17.7</td>
<td>14.4</td>
<td>8.0</td>
<td>20.0</td>
<td>36.3</td>
</tr>
<tr>
<td>Degree of urbanization (%)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very urban</td>
<td>14.8</td>
<td>63.1</td>
<td>41.4</td>
<td>40.4</td>
<td>41.8</td>
<td>25.2</td>
</tr>
<tr>
<td>Urban</td>
<td>23.2</td>
<td>19.9</td>
<td>28.8</td>
<td>32.5</td>
<td>32.2</td>
<td>25.1</td>
</tr>
<tr>
<td>Urban/rural</td>
<td>22.1</td>
<td>11.9</td>
<td>19.2</td>
<td>17.1</td>
<td>16.5</td>
<td>23.9</td>
</tr>
<tr>
<td>Rural</td>
<td>38.7</td>
<td>3.9</td>
<td>8.7</td>
<td>9.1</td>
<td>7.2</td>
<td>13.4</td>
</tr>
<tr>
<td>Very rural</td>
<td>16.1</td>
<td>1.3</td>
<td>1.9</td>
<td>0.9</td>
<td>2.3</td>
<td>5.0</td>
</tr>
<tr>
<td>Charlson Index (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>92.0</td>
<td>92.4</td>
<td>97.8</td>
<td>94.3</td>
<td>94.0</td>
<td>91.5</td>
</tr>
<tr>
<td>1–2</td>
<td>5.9</td>
<td>5.7</td>
<td>2.0</td>
<td>4.8</td>
<td>4.9</td>
<td>6.1</td>
</tr>
<tr>
<td>3–4</td>
<td>1.6</td>
<td>1.3</td>
<td>0.2</td>
<td>0.7</td>
<td>0.9</td>
<td>1.8</td>
</tr>
<tr>
<td>&gt;4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.0</td>
<td>0.2</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Person-years at risk</td>
<td>70564803</td>
<td>973425</td>
<td>373476</td>
<td>773828</td>
<td>244396</td>
<td>1158498</td>
</tr>
</tbody>
</table>

*Population density (number of residents per km²) at baseline. Very urban=>2000, urban=1001–2000, urban/rural=501–1000, rural=251–500, very rural=<251. IQR indicates interquartile range.
no significant differences in the incidence of ICH between Antillean, Turkish, and ethnic Dutch women.

**Subarachnoid Hemorrhage**

Among men, there were no significant differences in the incidence of SAH between the ethnic minority groups and the ethnic Dutch except for the lower incidence in Moroccans. Among women, Surinamese and Indonesians had a higher incidence, whereas Moroccan and Turkish had a lower incidence of SAH compared with ethnic Dutch women.

**Discussion**

Previous studies have generally shown increased incidence of stroke subtypes among ethnic minority and migrants groups as compared with the majority populations, but we could not confirm this for all ethnic minority groups in our study. The increased incidence was confirmed for the Surinamese population in our study. By contrast, Moroccans seem to have a lower incidence for all the various stroke subtypes compared with ethnic Dutch people. For the other ethnic groups, we found mixed results, with the incidence depending on stroke subtypes and sex.

The reasons for the large ethnic differences in the incidence of the various stroke subtypes observed in our present study are unclear. However, the ethnic differences reflect on the variations in the underlying risk factors. The relatively high incidence of stroke subtypes in the Surinamese population of predominantly West-African and South-Asian Indian descent, for example, may in part be because of the high prevalence of cardiovascular risk factors in these populations. In a previous
In the study, we found that the prevalence of hypertension was 2- to 3-fold higher in African Surinamese and South-Asia Surinamese people than in ethnic Dutch people. Uncontrolled hypertension is common among Surinamese populations, particularly among the African Surinamese men. In addition, diabetes mellitus and obesity are more common among ethnic minority groups as compared with ethnic Dutch people. Furthermore, a high prevalence of smoking has also been found among Surinamese and Turkish men compared with ethnic Dutch men. The high incidence of the various stroke subtypes found among some of the ethnic minority groups in the present study is consistent with the high incidence found among West-African and South-Asian descent populations in the United Kingdom, and African American and Hispanic people in the United States of America. The low incidence of overall stroke in Chinese people is consistent with the low incidence rate found in the Scottish Health and Ethnicity Linkage study. However, this present study shows that although the overall stroke incidence is lower, the incidence of ICH is higher in Chinese than in ethnic Dutch, emphasizing the need to assess various stroke subtypes in different ethnic groups. The high incidence of ICH among Chinese people that we found is consistent with the high incidence found in China. ICH is one of the leading causes of death and disability in China and has been linked to the apolipoprotein E polymorphism. In Western populations, for example, apolipoprotein E usually accounts for ≈10% of all strokes, but in many East-Asian populations, such as China, it accounts for approximately one third of all strokes. These findings suggest the need to assess the contribution of genetics to the high incidence of ICH observed in other ethnic minority groups.

Our findings have important clinical and public health implications. The high prevalence of major risk factors for stroke, such as uncontrolled hypertension in Surinamese and smoking in Turkish men, clearly corroborate with their high incidence of stroke subtypes and emphasize the urgent need for effective clinical management of blood pressure and smoking cessation prevention efforts among these ethnic
groups in the Netherlands. Effective blood pressure management confers significant benefit to stroke prevention and to stroke survivors by reducing risk of recurrent stroke and cardiovascular events.\textsuperscript{31} Observational studies have also shown that the elevated risk of stroke because of smoking declines after quitting and is eliminated within 5 years.\textsuperscript{32} The ethnic variations in the risk of stroke subtypes suggest potential etiologic differences between the ethnic groups and warrants further research to identify the root causes of these differences, especially among those ethnic minority groups in whom data on risk factors are currently lacking. Such information is crucial for designing effective primary and secondary preventative programmes that target those at high risk.

**Strengths and Limitations**

A major strength of our present study is that it is based on a nationwide database with large sample sizes, which allowed us to study incidence of the various types of stroke in several ethnic minority groups stratified by sex. There are also limitations to our study. Inherent to many national-level databases, we lack data on risk factors, such as hypertension, diabetes mellitus, smoking, alcohol, and diet, and therefore, we were unable to assess the direct contribution of the various risk factors to the observed ethnic differences. Nevertheless, we were able to shed light on the potential contributing factors to the observed difference, thanks to the previous studies on ethnic differences in risk factors in the Netherlands.\textsuperscript{18–21,26} Besides, we lack data on the various subtypes of IS. Moreover, we were unable to further stratify the analysis by age because of small numbers. The observed differences between the ethnic groups warrant a national-level effort to identify the root causes of the ethnic differences in the various stroke types, including data collection on the subtypes of IS in the Netherlands. Another limitation is that the ethnic minority groups were constructed on the basis of country of birth. Country of birth may reflect ethnicity fairly well in some ethnic groups,\textsuperscript{15} but it is likely to be an unreliable measure of ethnicity for other groups, such as Surinamese who are ethnically diverse. Notwithstanding, our earlier studies showed that major risk factors for stroke, such as hypertension and type 2 diabetes mellitus, are higher in both African Surinamese and South-Asian Surinamese than in ethnic Dutch people.\textsuperscript{18,19}

**Conclusions**

In conclusion, our current study has revealed ethnic differences in the risk of stroke subtypes. Surinamese people have an increased risk, whereas Moroccan people have a reduced risk for almost all stroke subtypes as compared with ethnic Dutch people. Among the other ethnic minority groups, the risk seems to depend on the stroke subtype and sex. These findings underscore the need to identify the root causes of these ethnic differences in stroke outcomes. Such information is essential for planning effective primary and secondary prevention programmes that target those at high risk, such as Surinamese.

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**Disclosures**

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Ethnic Disparities in Ischemic Stroke, Intracerebral Hemorrhage, and Subarachnoid Hemorrhage Incidence in The Netherlands
Charles Agyemang, Aloysia A.M. van Oeffelen, Marie Norredam, L. Jaap Kappelle, Catharina J.M. Klijn, Michiel L. Bots, Karien Stronks and Ilonca Vaartjes

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