We have previously presented analyses of the relationship between potential risk factors for stroke and stroke mortality in 20 years of follow-up in men and women in the Renfrew/Paisley study.1 We now compare those results with similar analyses of risk factors with stroke incidence, as defined by having a hospital discharge with a main diagnosis of stroke and compare this with the associations between risk factors and stroke mortality.

Methods—In the early to mid-1970s, when they were 45 to 64 years of age, 7052 men and 8354 women from the Renfrew/Paisley prospective cohort study in Scotland were screened. Risk factors measured included blood pressure, blood cholesterol and glucose, respiratory function, cardiothoracic ratio, smoking habit, height, body mass index, preexisting coronary heart disease, and diabetes. These were related to stroke incidence over 20 years of follow-up. Results—Diastolic and systolic blood pressure, smoking, cardiothoracic ratio, preexisting coronary heart disease, and diabetes were positively related to stroke incidence for men and women, whereas adjusted FEV$_1$ (forced expiratory volume in 1 second) and height were negatively related. Cholesterol was not related to stroke. Glucose for nondiabetic subjects had a U-shaped relationship with stroke. Body mass index was not clearly related to stroke, although participants with the highest body mass index had the highest stroke rate. Former smokers had similar stroke rates to never-smokers. Tests between the associations of risk factors and stroke incidence revealed these were not statistically different from the associations with stroke mortality.

Conclusions—The risk factors had a similar effect on stroke incidence as on stroke mortality. Epidemiological studies with information on stroke mortality are likely to give results applicable to stroke incidence. (Stroke. 2000;31:1893-1896.)

Key Words: epidemiology ▪ prospective studies ▪ risk factors ▪ stroke prevention
Results

In the 20-year follow-up period, 472 men and 557 women had a hospital discharge for stroke. Clear positive relationships were seen between both systolic and diastolic blood pressure and stroke in men and women (Table 1). Men and women in the highest blood pressure quintiles (systolic: ≥167 mm Hg for men, ≥172 mm Hg for women; diastolic: ≥97 mm Hg for men and women) had more than double the stroke incidence rate of those in the lowest quintiles. No relationship was seen between cholesterol and stroke in men and women. The relationship between glucose (excluding diabetic subjects) and stroke appeared U shaped in both men and women, with the highest rate seen in the lowest quintile. Adjusted FEV₁ was inversely related to stroke for men and women, with strong significant trends. Cardiothoracic ratio was positively related to stroke for both men and women. The relationship of body mass index with stroke was less clear, but men and women with the highest body mass index had the highest stroke rate. Height was negatively associated with stroke.

There was a dose-response relationship between cigarette smoking and stroke for men (Table 2). Ex-smokers had stroke rates similar to never-smokers.

The relative rates of stroke for a 1-SD change in each risk factor are shown in Table 3 and compared with previously published relative rates of stroke mortality for a 1-SD change in each risk factor. Tests between the associations were all nonsignificant. The relative rates of stroke incidence and stroke mortality are also shown for diabetes and preexisting CHD. For diabetic subjects, the relative rate for stroke mortality was higher than that for stroke incidence for both men and women, but tests between them were also nonsignificant.

Discussion

The Renfrew/Paisley study is unique in the United Kingdom in having a large general population cohort of both men and women with comprehensive information on risk factors in middle age and 20 years of follow-up for both stroke mortality and incidence. Sufficiently large numbers of participants had hospital stays due to stroke to enable relationships between risk factors and stroke incidence to be investigated. If participants had nonfatal strokes at home and were not seen between both systolic and diastolic blood pressure to the standard. Cox proportional hazards regression models were calculated by a life table approach and standardized by 5-year age groups, with the age distribution of the Renfrew/Paisley cohort used as the standard. Cox proportional hazards regression models were used to calculate trends for each continuous variable and to calculate relative rates for a 1-SD increase or decrease for each continuous variable. The difference between relative rates for stroke incidence and stroke mortality was tested by standardized normal deviate tests.
admitted to hospital, then no information was available to the study team. Contemporary estimates suggest that 70% of stroke patients are admitted to hospital,9 with younger stroke sufferers being more likely to be admitted.10 The median age of stroke admission in our study was 70.6 years, and given the age at entry of our participants, no strokes could have occurred over the age of 85, after which admission rates become low. Therefore, most nonfatal strokes are likely to have been ascertained through stroke discharge data. It is also unlikely that risk factors for strokes leading to hospital admission are different in any considerable way from risk factors for strokes that are not admitted.

It is important to know whether risk factors have the same effect on stroke incidence as on stroke mortality. If the risk is similar for incidence and mortality, then measures that have been shown to reduce risk will prevent nonfatal stroke and consequential disability, which has quality-of-life implications and health service resource implications. We have demonstrated that in this cohort, risk factors for stroke had a similar effect on stroke incidence as on stroke mortality. When all the risk factors were simultaneously entered into a multivariate model, most retained a statistically significant association with stroke incidence in a similar way to multivariate analysis of stroke mortality in this cohort1 (results not shown).

Raised blood pressure is an established risk factor for both stroke incidence11,12 and mortality.13,14 The 12-year follow-up of the Oslo study of men found blood pressure to be significantly related to stroke mortality and incidence, with mortality being predicted better than incidence.15 Cholesterol was not found to be related to stroke incidence or mortality, but this may mask a relationship of cholesterol with some stroke subtypes.16 Glucose in nondiabetic subjects was significantly related to stroke incidence and mortality in women but not men. However, glucose was not measured for all sectors of the Paisley cohort and was missing for 4703 people. The Oslo study failed to find significant relationships between glucose and stroke incidence or mortality.15 Cardiothoracic ratio and FEV1 have not generally been measured in other studies, but here both were related to stroke incidence in the same way as mortality. Body mass index was not clearly associated with stroke incidence or mortality in the present study. The Oslo study found no relationship between body mass index and stroke mortality or incidence.15 Generally, there is less evidence of obesity being related to stroke, although it could be acting through its association with other risk factors for stroke, such as elevated blood pressure, blood glucose, and obstructive sleep apnea.11,17 Height was inversely associated with stroke incidence and mortality. In the British Regional Heart Study of men, an inverse association was seen with fatal but not nonfatal stroke.18 Height was inversely associated with stroke events for men but not women in a study in southeastern New England.19 In the Oslo study, there was a suggested inverse association between height and stroke incidence and mortality.15

Smoking has been seen as a risk factor for stroke incidence in other studies.11,15,20,21 In the Oslo study of men, smoking was found to be a stronger predictor of stroke mortality than incidence.15 A dose response was seen with cigarette smoking, and smoking cessation reduced the stroke incidence risk. This was also seen for stroke mortality in the present cohort.1 Other studies have shown this effect,12 which suggests that a real way to reduce both stroke occurrence and mortality is to

TABLE 3. Comparison of Relationships of Risk Factors With Stroke Incidence and Stroke Mortality

<table>
<thead>
<tr>
<th></th>
<th>Incidence</th>
<th>Mortality*</th>
<th>Test for Difference† (P)</th>
<th>Incidence</th>
<th>Mortality*</th>
<th>Test for Difference† (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative rate for 1-SD increase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP</td>
<td>1.45 (1.33–1.58)</td>
<td>1.50 (1.35–1.66)</td>
<td>0.62</td>
<td>1.43 (1.32–1.55)</td>
<td>1.37 (1.25–1.51)</td>
<td>0.52</td>
</tr>
<tr>
<td>DBP</td>
<td>1.37 (1.26–1.48)</td>
<td>1.44 (1.30–1.59)</td>
<td>0.45</td>
<td>1.40 (1.29–1.51)</td>
<td>1.42 (1.29–1.55)</td>
<td>0.81</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>1.04 (0.95–1.15)</td>
<td>0.94 (0.83–1.05)</td>
<td>0.16</td>
<td>0.98 (0.90–1.06)</td>
<td>0.91 (0.82–1.02)</td>
<td>0.33</td>
</tr>
<tr>
<td>Glucose</td>
<td>1.07 (0.98–1.18)</td>
<td>1.10 (0.99–1.23)</td>
<td>0.71</td>
<td>1.12 (1.02–1.24)</td>
<td>1.21 (1.11–1.33)</td>
<td>0.24</td>
</tr>
<tr>
<td>Cardiotoracic ratio</td>
<td>1.18 (1.07–1.29)</td>
<td>1.20 (1.07–1.34)</td>
<td>0.82</td>
<td>1.20 (1.10–1.31)</td>
<td>1.15 (1.04–1.28)</td>
<td>0.54</td>
</tr>
<tr>
<td>Body mass index</td>
<td>1.10 (1.01–1.21)</td>
<td>1.01 (0.90–1.14)</td>
<td>0.25</td>
<td>1.10 (1.02–1.19)</td>
<td>1.07 (0.97–1.18)</td>
<td>0.67</td>
</tr>
<tr>
<td>Relative rate for 1-SD decrease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted FEV1</td>
<td>1.23 (1.12–1.34)</td>
<td>1.27 (1.14–1.41)</td>
<td>0.66</td>
<td>1.22 (1.12–1.32)</td>
<td>1.24 (1.31–1.37)</td>
<td>0.75</td>
</tr>
<tr>
<td>Height</td>
<td>1.16 (1.06–1.27)</td>
<td>1.21 (1.08–1.35)</td>
<td>0.60</td>
<td>1.14 (1.05–1.24)</td>
<td>1.13 (1.03–1.25)</td>
<td>0.88</td>
</tr>
<tr>
<td>Relative rate associated with 20 more cigarettes/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.52 (0.72–3.21)</td>
<td>2.89 (1.49–5.62)</td>
<td>0.21</td>
<td>2.83 (1.63–4.90)</td>
<td>3.98 (2.29–6.91)</td>
<td>0.39</td>
</tr>
<tr>
<td>Preexisting CHD</td>
<td>1.63 (1.34–1.97)</td>
<td>1.63 (1.28–2.06)</td>
<td>0.99</td>
<td>1.52 (1.28–1.81)</td>
<td>1.74 (1.42–2.14)</td>
<td>0.32</td>
</tr>
</tbody>
</table>

SBP indicates systolic blood pressure; DBP, diastolic blood pressure. *(From Reference 1. †Difference between incidence and mortality.)
encourage smoking cessation. Diabetes has been recognized as a risk factor for stroke incidence\textsuperscript{11,20} and mortality.\textsuperscript{22,23}

Preexisting CHD was significantly related to stroke, confirming other studies.\textsuperscript{11,20}

To conclude, we have found that the risk factors considered had similar relationships for stroke incidence as stroke mortality, and control of some risk factors could be expected to reduce stroke incidence and any resulting disability, in addition to reducing stroke mortality. Epidemiological studies with only mortality outcomes are likely to give results that are also applicable to stroke incidence.

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Comparison of Risk Factors for Stroke Incidence and Stroke Mortality in 20 Years of Follow-Up in Men and Women in the Renfrew/Paisley Study in Scotland
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