

# Scoring system to identify men at high risk of stroke: a strategy for general practice

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## SUMMARY

**Background.** *The major risk factors for stroke are well described and there is good evidence that the risks associated with hypertension and cigarette smoking are reversible by appropriate interventions. However, if disease prevention measures are to be efficient, it is important that a system which can identify individuals at high risk of stroke be available for use in general practice.*

**Aim.** *A study was therefore undertaken to design an effective and practical system for detecting men aged 40 to 59 years at high risk of stroke in primary care.*

**Method.** *Stroke incidence and risk factor data were examined in a cohort of 7735 men aged 40 to 59 years who had taken part in the British regional heart study. Analysis was performed using data from initial entry into the study and then from five and 11.5 years of follow up. Subjects were randomly selected from the age-sex register of one general practice in each of 24 different towns throughout the United Kingdom, representing the full range of cardiovascular mortality rates.*

**Results.** *A simple scoring system derived from logistic regression using age, systolic blood pressure, current cigarette consumption, and evidence of anginal chest pain was able to detect more than 80% of all strokes occurring within five years in the top fifth of the score distribution. The inclusion of other risk factors for stroke did not increase the score's predictive ability. The combination of smoking and hypertension, while much less sensitive than the scoring system, was a better indicator of risk than any single risk factor, all of whose predictive values were poor.*

**Conclusion.** *Based on readily measured variables, this scoring system could be used in general practice to identify men at high risk of stroke who would benefit from further intervention. Effective identification of high risk individuals requires assessment of the combined effects of multiple risk factors.*

**Keywords:** *stroke; morbidity risk factors; men's health; health status measurement; lifestyle; rating scales.*

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Submitted: 17 February 1994; accepted: 25 August 1994.

© *British Journal of General Practice*, 1995, 45, 185-189.

## Introduction

STROKE is major cause of mortality and considerable disability in the United Kingdom, with 80 000 fatal and up to 200 000 non-fatal events occurring each year.<sup>1,2</sup> The prevention of stroke has therefore been accepted as an important goal in *The health of the nation* white paper.<sup>3</sup> The key risk factors for stroke have been identified and include high blood pressure,<sup>4</sup> cigarette smoking,<sup>5</sup> and low levels of physical activity<sup>6</sup> — factors which are also related to coronary heart disease.<sup>7,8</sup> High plasma cholesterol level, although an established risk factor for coronary heart disease, is not so clearly related to stroke.<sup>9</sup>

Both population-based strategies and strategies for those at high risk have been advocated for the prevention of stroke.<sup>10,11</sup> However, evidence suggests that prevention strategies for those at high risk are likely to be more effective for stroke than for coronary heart disease: risk factors for stroke may be more clustered,<sup>12</sup> and there is stronger evidence that changes in risk factor levels can reduce stroke risk. In particular, treatment of high blood pressure results in a greater reduction in risk of stroke than of coronary heart disease.<sup>13</sup> Moreover, the reduction in risk associated with stopping smoking may occur more quickly for stroke than for coronary heart disease.<sup>9,14,15</sup> Prevention strategies for those at high risk have also been advocated for coronary heart disease, with the development of scoring systems for the identification of individuals at high risk.<sup>16,17</sup> Despite their ability to aid detection of these subjects (between 41% and 59% of victims in the top quintile of risk over five years), their use has been limited in practice.<sup>18</sup> Doubt has also been cast upon the value and effectiveness of blanket health promotion measures in the light of recent intervention studies in primary care.<sup>19,20</sup>

In order to evaluate further strategies for those at high risk of stroke, a study was undertaken to examine the effectiveness of different strategies in order to identify subjects at high risk, using data from a large prospective epidemiological study of cardiovascular disease.

## Method

The British regional heart study is a national prospective investigation into the fundamental causes of coronary heart disease and stroke. In 1978-80, approximately 10 000 men aged 40-59 years were drawn at random from a general practice in each of 24 towns in England, Wales and Scotland and invited to participate in the study, of whom 7735 agreed (78%). The criteria for selecting the town, practice and subjects, as well as the data handling have been described in detail elsewhere.<sup>21</sup>

### Baseline assessment

A detailed health questionnaire on personal and family history and a modified Rose angina questionnaire<sup>22</sup> were administered to the participants. A physical examination was also conducted. Of the many variables studied, 15 were examined here, of which six were continuous variables: age, blood pressure (systolic and diastolic), body mass index, haematocrit and cholesterol level. Three grouped variables were studied: smoking status, physical activity and alcohol intake. The other six were categorical variables: evidence of previous myocardial infarction on electrocardiogram, angina, left ventricular hypertrophy on electrocardiogram, previous myocardial infarction or stroke, parental history

of fatal myocardial infarction or stroke, and diabetes. History of characteristic anginal pain was determined using the modified Rose questionnaire<sup>22</sup> which is based on the site, frequency, duration, precipitants, and effects of pain. Only responses indicative of definite ischaemic cardiac pain were considered as being positive.

### Follow up

All men were followed up for all-cause mortality and for fatal and non-fatal cardiovascular events, contact being maintained through their general practitioner with 99% of surviving men. Information on deaths was obtained by tagging each of the men through the National Health Service central registries in Southport and Edinburgh. Non-fatal events were ascertained through reporting by general practitioners, supplemented by regular reviews of all patient records at 18 month intervals.<sup>23</sup> In addition the men were sent a postal questionnaire at five years, to which 98% responded. Non-fatal strokes were defined as those which produced a focal neurological deficit of sudden onset which was present for longer than 24 hours. Fatal episodes were those deaths ascribed to *International classification of diseases* (ninth revision) codes 430–438. A total (that is, fatal and non-fatal) of 61 and 177 cases of stroke had occurred by five and 11.5 years, respectively.

### Analysis

To perform the analysis, each of the continuous variables considered was ranked into quintiles (that is, equal fifths) of their distribution of men, and the number of stroke cases occurring in each quintile used to calculate incidence, expressed as cases per 1000 patients per year. Categorical and grouped variables such as anginal chest pain and smoking status were divided into logical groups and the incidence calculated similarly. Factors associated with stroke were identified using univariate logistic regression on data from five year follow up. All those factors significantly associated with stroke (that is, where  $P < 0.05$ ) were then included in a multiple logistic regression analysis. Factors remaining independently associated with stroke were then combined to form a score based on their regression coefficients. The optimum combination of these factors was used which maximized the predictive ability of the score yet minimized the number of factors used.

Finally, the coefficients were simplified and adjusted for practical purposes such that the top quintile of the score began at a value of 1001.

## Results

### Risk factors — univariate analysis

Tables 1 and 2 show all the significant risk factors, and those considered to be of interest but which showed no association with stroke. The relative risk for each factor has been calculated as the ratio of the incidence in the highest and lowest quintiles or groups, and for categorical variables, from the ratio of those with to those without the characteristic. The strongest risk factor for stroke was found to be age, with a relative risk of 12.0, followed by systolic blood pressure with a relative risk of 6.2. However, all the variables examined, with the exception of body mass index, haematocrit result, cholesterol level, alcohol intake, history of diabetes and parental history of fatal myocardial infarction or stroke showed a strong association with risk of stroke. The proportion of all cases of stroke occurring in the highest quintile varied from 18% to 61% for the continuous variables, and 16% to 33% for the grouped variables (Table 1). Among the categorical variables (Table 2), a history of cardiovascular disease or anginal chest pain were positively associated with risk of stroke at five years.

### Combined effects — multivariate analysis

The independent contribution of each of the factors presented was examined in a multiple logistic regression model, including all factors, using the five year follow-up data. Age, systolic blood pressure, number of cigarettes currently smoked, evidence of left ventricular hypertrophy or myocardial infarction on electrocardiogram, and evidence of angina retained independent effects in the analysis at a 10% level of significance. A term for interaction between smoking and blood pressure was tested and found not to be statistically significant.

Using these factors from the regression analysis, a scoring system was developed to predict risk of stroke employing the weighted regression coefficients of each of these variables. The model with the best yield included age, systolic blood pressure, current smoking status and angina. Although the electrocardio-

**Table 1.** Risk factors for stroke at five years (continuous variables and grouped variables).<sup>a</sup>

Variable	Cases of stroke per 1000 men per year					Relative risk (5 years)	% of strokes in top quintile
	1	2	3	4	5		
<i>Incidence by quintile<sup>b</sup></i>							
Age	0.26	0.13	1.94	2.46	3.10	12.0	39.3
Systolic blood pressure	0.77	0.78	0.91	0.65	4.80	6.2	60.7
Diastolic blood pressure	1.29	1.03	0.90	1.31	3.37	2.6	42.6
Body mass index	1.03	1.68	1.82	1.94	1.42	1.4	18.0
Haematocrit result	1.64	1.46	1.47	1.52	1.93	1.2	27.1
Cholesterol level	1.61	1.30	1.07	2.23	1.47	0.9	18.3
<i>Incidence by group</i>							
Cigarette smoking <sup>c</sup>	0.75	2.37	3.44	NA	NA	4.6	32.8
Physical activity <sup>d</sup>	0.73	1.33	1.36	2.05	2.92	4.0	16.7
Alcohol intake <sup>e</sup>	2.57	1.41	1.18	1.67	2.40	0.9	16.4

<sup>a</sup>Relative risk at five years and percentage of strokes in top quintile calculated from raw data rather than rounded data presented here. <sup>b</sup>Mean number of men in each quintile for each variable = 1532, range 1056 to 1769 men. <sup>c</sup>Self-reported cigarette consumption: group one = non-smokers/ex-smokers (4534 men); group two = smoke 1–20 cigarettes per day (2023 men); group three = smoke >20 cigarettes per day (1162 men). <sup>d</sup>Physical activity: group one most active, 1633 men; group two 1205 men; group three 1761; group four 2345 men; group five least active, 686 men, according to previously validated scoring technique.<sup>8</sup> <sup>e</sup>Alcohol intake based on number of units of alcohol per week: group one = non/ex-drinker (466 men); group two = occasional (1845 men); group three = 1–15 units weekly (2544 men); group four = 15–42 units weekly (2042 men); group five = >42 units weekly (832 men). NA = not applicable.

**Table 2.** Risk factors for stroke at five years (categorical variables).<sup>a</sup>

Variable	Cases of stroke per 1000 patients per year	Relative risk (5 years)	% of strokes in positive group
Evidence of previous MI on ECG			
Yes ( <i>n</i> = 242)	6.61	4.7	13.1
No ( <i>n</i> = 7485)	1.42		
Angina			
Yes ( <i>n</i> = 367)	4.90	3.5	14.7
No ( <i>n</i> = 7353)	1.41		
Left ventricular hypertrophy on ECG			
Yes ( <i>n</i> = 464)	4.74	3.4	18.0
No ( <i>n</i> = 7261)	1.38		
Previous MI or stroke			
Yes ( <i>n</i> = 328)	4.88	3.4	13.1
No ( <i>n</i> = 7405)	1.43		
Parental history of fatal MI or stroke			
Yes ( <i>n</i> = 2892)	1.66	1.2	42.1
No ( <i>n</i> = 4654)	1.42		

*n* = number of men in group. MI = myocardial infarction. ECG = electrocardiogram. <sup>a</sup>Relative risk at five years and percentage of strokes in positive group calculated from raw data rather than rounded data presented here.

graphically derived variables were statistically significant they did not increase the yield of the score, and they were therefore omitted. The rates of stroke for each fifth of the score and the proportion of all cases are shown in Table 3. Scores ranged from 652 to 1321 with the highest quintile indicated by scores greater than 1000. Stroke cases were clustered, with 82.0% of all cases at five years occurring in the top fifth of the score. The relative risk comparing highest and lowest quintiles was 16.7 (95% confidence interval (CI) 5.2 to 53.4). The highest risk quintile was associated with an extremely high stroke incidence rate, equivalent to a five-year cumulative risk of more than 30 per 1000 or 3%. Examining performance across the range of ages, the score identified approximately equal proportions of strokes in the 40–49 years and 50–59 years age groups. Excluding those with a past history of stroke or myocardial infarction at baseline screening did not reduce the sensitivity of the score either, with 84.9% of 53 remaining strokes in the highest quintile. It would appear, therefore, that individuals with previous myocardial infarction or stroke are not a higher risk subgroup than those identified using the top quintile of the score, and from this evidence would not need any additional special consideration.

**Table 3.** Stroke rates in the score quintiles.<sup>a</sup>

	Quintile				
	1	2	3	4	5
Score range	652–817	818–881	882–934	935–1000	1001+
% of cases of stroke ( <i>n</i> = 61)	4.9	1.6	0	11.5	82.0
Risk rate per 1000 patients per year	0.39	0.13	0	0.91	6.47

*n* = number of cases of stroke at five years. <sup>a</sup>Total of 1545 men in each quintile.

### Risk score calculation

The weights used in deriving an individual's risk factor score for stroke are as follows:

$$\begin{aligned} \text{Score} = & 9 \times \text{age (years)} \\ & + 2.85 \times \text{systolic blood pressure} \\ & + 70 \text{ if angina present} \\ & + 90 \text{ if smokes 1–20 cigarettes per day} \\ \text{or} & + 130 \text{ if smokes more than 20 cigarettes per day} \end{aligned}$$

Examples of the application of the score for an individual are considered:

- A man aged 50 years, non-smoker, systolic blood pressure of 120 mmHg with no angina will have a score of  $(9 \times 50) + (2.85 \times 120) = 792$ , falling into the bottom quintile of risk.
- A man aged 50 years, smoking 20 cigarettes per day, with a systolic blood pressure of 160 mmHg and angina will have a score of  $(9 \times 50) + (2.85 \times 160) + 90 + 70 = 1066$ , falling into the highest quintile.

### Risk score versus single risk factors

A comparison of the prediction of future strokes using the scoring system with future strokes predicted by single risk factors alone is shown in Table 4, using hypertension, smoking, and the top quintile of risk score. The proportion of strokes identified is a measure of sensitivity, and the number of men needing to be screened to identify each case, of specificity. While the risk score was the most sensitive method of detection, hypertension and cigarette smoking alone also identified a substantial proportion of cases. However, these markers were not particularly specific; they required considerably larger numbers of men to be screened per case detected. The combination of cigarette smoking and hypertension was very specific, although it identified fewer than half of stroke cases.

### Prediction of risk over a longer follow-up period

Results from 11.5 years of follow up showed a weakening of the predictive ability of all methods of stroke identification (single risk factors, combination of risk factors or risk score) using these data. The relative risk of stroke between the top and bottom quintiles of the risk score was 13.1 (95% CI 6.4 to 26.8) at 11.5 years with only 59.3% of all 177 strokes identified, compared with 16.7 (95% CI 5.2 to 53.4) seen at five years. The score remained a more effective predictor of stroke risk than single risk factors.

**Table 4.** Comparison of stroke risk identification using smoking and hypertension risk factors and top quintile of risk score.

	Risk group			
	Hypertensive <sup>a</sup>	Current smoker	Hypertensive <sup>a</sup> and current smoker	Top quintile of risk score
No. (%) of all men in risk group	1667 (21.6)	3185 (41.3)	679 (8.8)	1545 (20.0)
No. (%) of all strokes occurring in risk group	40 (65.6)	44 (72.1)	27 (44.3)	50 (82.0)
Risk rate (cases per 1000 patients per year) <sup>b</sup>	4.8	2.8	8.0	6.5
No. of men screened per case	42	73	26	31

<sup>a</sup>Hypertensive = systolic blood pressure >160 mmHg. <sup>b</sup>Overall stroke rate in the study population = 1.58 cases per 1000 per year.

## Discussion

Stroke offers particular opportunities for prevention strategies for those at high risk, more so than coronary heart disease. The treatment of high blood pressure,<sup>13,24</sup> reduction or avoidance of smoking, and the use of antiplatelet agents in those with evidence of cardiovascular disease<sup>25</sup> have all shown clinical evidence of benefit. These measures are all applicable in primary care and may make an important contribution to the targets discussed in *The health of the nation*.<sup>3</sup> This study suggests that a simple multifactorial scoring system can identify a group of subjects at high risk of stroke much more effectively than single risk factors alone.

The stroke risk factor score developed from the British regional heart study findings has several advantages over risk factor scores developed for coronary heart disease. First, the highest quintile of the score identified 82% of cases occurring within five years. This means that the work involved in intervening in the top 20% of the population has the potential for dealing with the bulk of stroke prevention required in a practice. This yield of high risk individuals compares favourably with scoring systems for coronary heart disease,<sup>16,17</sup> which at best identify 59% of cases. Secondly, the score does not require investigations or a detailed medical history and could therefore be applied opportunistically by nursing staff at low cost. Thirdly, the score is simple to calculate, and can be derived using a pocket calculator or a practice computing system appropriately programmed.

The calculation of the risk score in this analysis is based on data from cases of stroke occurring within five years of follow up. This period is appropriate and meaningful to both patient and the primary care team. An analysis of data from more extended follow up of 11.5 years revealed an attenuation of the risk prediction from the same scoring system. This weakening of prediction over time is not surprising: the influence of initial risk factor measurements on outcome becomes attenuated with increasing follow up, and risk factor modification may occur. Also, deaths of a larger proportion of the highest risk individuals are likely to occur. However, while the score retains considerable predictive power up to 11.5 years, its greatest practical value may be over the first five year period.

While it identifies a group at high risk of stroke, the scoring system does not itself direct clinical management. For most patients at high risk, management of current cigarette smoking and hypertension is likely to be important. However, modification of other factors such as physical activity and alcohol intake may also be important in many patients. Inactivity for example is associated with up to a three-fold increased risk of stroke<sup>6</sup> and is widely prevalent, reported by up to 80% of men.<sup>26</sup>

The population on which this study was based is likely to be reasonably representative of middle-aged British men. However, the use of a scoring system in a population other than that in which it was developed is unlikely to give such a good yield; further experience in other populations would therefore be valuable. The score's applicability in older men and women is of particular interest. While smoking and high blood pressure are similarly related to stroke risk in women and older people<sup>5,27,28</sup> older subjects will have higher, and middle-aged women, lower, absolute risks and hence scores. Thus to identify an appropriately sized high-risk group, different thresholds may need to be set.

A general practitioner with an average list size of 2000 people will have at least 500 middle-aged and older people of whom 100 will, on average, be in the highest stroke risk score quintile. Since this group can expect to suffer at least six strokes per 1000 patients per year, treatment that reduces stroke occurrence by 50%, such as treatment of high blood pressure,<sup>13,29</sup> will equate with the prevention of one stroke case for every 100 people treated for three years. The use of the score may identify up to 82% of stroke cases over five years in 20% of the population, while

the use of smoking and hypertension combined can identify 44% of strokes in 9% of the population. The choice between these methods is likely to be influenced by the complexity of the score, the size of the high risk group identified, and the different yields and perceptions of sensitivity and specificity.

Scoring systems may appear to be a complicated way of stating the obvious: stop smoking and treat high blood pressure. However, the scoring system draws attention to the increased absolute risks associated with age and a history of angina and thereby alerts the primary care team to the increased importance (and benefits in terms of strokes prevented per 100 patients treated) of intervention in these older individuals with evidence of cardiovascular disease. Secondly, these findings emphasize the importance of considering risk factors in combination. Using both smoking and hypertension to identify individuals at risk of stroke, although less sensitive than the risk score, is still much better than basing action on single risk factors alone which have poor specificity—currently the basis of the health promotion guidelines for general practice.<sup>30</sup>

We recommend that primary care teams who wish to use the stroke risk score should integrate its calculation with routine monitoring for health promotion purposes. Those patients with scores over the threshold of 1000 which defines the highest quintile of risk should then be assessed by a nurse or doctor for the most appropriate means of intervention. This intervention need not be restricted to those risk factors used to identify individuals in the first place. It is likely that for most patients this will include control of high blood pressure by non-pharmacological or pharmacological treatment, smoking cessation, low dose aspirin for those with a history of angina, and exercise and advice.

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#### Acknowledgements

This study was supported by the Stroke Association. The British regional heart study research group also receives support from the British Heart Foundation and the Department of Health. W C was supported by the Stroke Association. O P was supported by the Institute of Alcohol Studies.

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