PAPERS AND SHORT REPORTS

Mortality from and incidence of stroke in Stockholm

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Abstract

To study trends in the incidence of and mortality from stroke in Stockholm during 1974-81 all cases (n=56 566) of stroke in patients aged over 40 were identified from the Swedish Cause of Death Register and the Inpatient Care Register. Information on the population at risk was obtained from the civil registration system. A multiplicative model was used to control for changes in the distribution of age during the study.

Mortality from stroke decreased annually throughout the study by a mean of 2·3% for men and 3·5% for women. This favourable development was not accompanied by a similar decrease in the incidence of stroke.

In men the total incidence (including recurrent strokes) and incidence of first stroke increased continuously. In women the total incidence showed virtually no change, whereas the incidence of first stroke decreased somewhat. These findings, in addition to an expected shift of age profile in the population towards more elderly people, should be considered in the planning of future health care resources.

Introduction

A steady decline in mortality from stroke has been noted in Sweden and most other industrialised countries since at least the early 1950s,[1 2] but reasons for this decline have not yet been explained fully. Many workers attribute the decline to advances in the treatment of high blood pressure.[1-4] Among other factors suggested are changes in medical care and lifestyle.[4]

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It is not known whether the decline in mortality is paralleled by a similar decline in the incidence of new strokes or whether there has been a change in case fatality. Thus the object of this study was not to determine the annual incidence and mortality but to elucidate time trends in both the incidence of and mortality from stroke in Stockholm during 1974-81.

Patients and methods

Sweden has a highly efficient civil registration system. On the basis of this system the Swedish Cause of Death Register and the medical information systems in the county councils, which contain comprehensive Inpatient Care Registers, have been developed.

SELECTION OF CASES

To find cases of stroke that had occurred in Stockholm during the study period information was selected from the registers. All patients aged 40 and over who were admitted to hospital with a diagnosis of stroke (Nordic version of International Classification of Diseases code 431-438.99[5]), were resident in Stockholm, and had been discharged from hospital during 1974-81 were selected from the Inpatient Care Register. All residents of Stockholm aged 40 and over who died during 1974-81 in whom the underlying cause or one of the contributory causes of death was stroke (ICD code 431-438.9) were selected from the Cause of Death Register. Cases of stroke were defined from these two sets of data. For patients who had suffered more than one stroke only those who suffered a second event at least 21 days after a previous one were considered to be new cases, in accordance with previous studies.[6] Details of the problems and methods connected with the use of these registers for epidemiological purposes have been described elsewhere.[7]

During 1974-81 there were 56 566 cases—that is, events—of stroke in the population of Stockholm aged 40 and over (see table I). Of these cases, which included both post-stroke and recurrent stroke diagnoses, 26 558 were in men (median age 72) and 30 008 in women (median age 78). The total number of subjects who had a diagnosis of stroke (at least once) during the period was 38 067. Of these, 17 355 were men and 20 712 women. During the study a total of 6782 men and 9464 women aged 40 and over died. Table I shows the total number of patients and deaths from stroke by year of occurrence.

Using the Civil Registration System, we calculated the population at risk for each of the eight years 1974-81 by sex and age (5 year age groups). During 1974-81 the mean numbers of men and women aged 40 and over were 290 643 and 349 408, respectively.

TABLE I—*No of patients with a diagnosis of stroke* at discharge from hospital and deaths due to stroke by year and sex*

	No of patients			No of deaths		
	Men	Women	Total	Men	Women	Total
1974	2914	3428	6342	849	1137	1986
1975	2980	3538	6518	855	1223	2078
1976	3321	3647	6968	896	1241	2137
1977	3159	3601	6760	820	1145	1965
1978	3353	3766	7119	846	1209	2055
1979	3464	3897	7361	816	1189	2005
1980	3534	3958	7492	830	1175	2005
1981	3833	4173	8006	870	1145	2015
Total	26558	30008	56566	6782	9464	16246

*Includes post-stroke diagnoses.

STATISTICAL ANALYSIS

In the analysis men and women were treated separately. A multiplicative model was used to control for changes in the age distribution during the study.[8] This model implies that the rate in one age group for one year is defined as a product of an age factor (α), which is the same for all years during the period, and a time factor (β), which may differ between the years but is the same in all age groups. Thus if i denotes age group, j years of occurrence, and I incidence rate, I_{ij} is taken as the product $\alpha_i \times \beta_j$. Estimates of α:s and β:s, where s stands for plural estimates, were obtained by means of regression analysis. The time factor may be interpreted as the age standardised relative risk of developing (or dying from) stroke in one specific year compared with the first year of the period studied.[8] In addition, to describe trends the average annual change in incidences (or mortalities) was estimated by modifying the model by postulating the time factor to be exponential ($I_{ij}=\alpha_i \times \beta^j$).

Confidence intervals of 95% were computed for the relative risks as well as for point estimates of time trends. To investigate the adequacy of the multiplicative model the individual residuals were examined and a χ^2 test performed. The model seemed to fit the data, and in all cases, except for young women, the results were not significant (see figs 1 and 2 and tables II and III).

Analysis of the incidence of stroke was also carried out separately for different diagnoses.

Apart from calculating the total incidence of stroke, in which each subject may contribute more than once, we also wanted to estimate the incidence of the first stroke during 1974-81. As the civil registration system is based on unique individual identification numbers we were able to detect all recurrent events of stroke arising in subjects who had suffered a previous stroke during 1974-81. This gave us a fairly good estimate of the number of cases of first strokes in 1981. A few patients with recurrent strokes may have been included, however—that is, those who had had a previous stroke before 1974 (but not in the years 1974-80). Thus to calculate the incidence of first stroke during the whole period 1974-81, not only was the information in the actual database needed but patients who had suffered a previous stroke before 1974 had also to be taken into account.

Suppose A_{ij} is the number of subjects in age group i with a diagnosis of stroke during year j. A is then known for the years 1974-81. Furthermore, let γ_{ikl} be the probability that a subject belonging to age group i with a diagnosis of stroke in year k will have a recurrent event of stroke after l years (but not in the interim). For relevant l values γ is known for k=1974-81. Finally, suppose B_{ij} is the number of subjects belonging to age group i with a first event of stroke during year j. Then for the period 1968-73 the calculation of the number of first strokes is as follows (where i=1 . . . 12 and j=1974-81):

$$B_{ij}=A_{ij}-\sum_{k=1968}^{j-1} A_{ik}\times\gamma_{ik(j-k)}$$

As A and γ are unknown for the period 1968-73 and the Inpatient Care Register was considered to be unreliable before 1974 we had to estimate

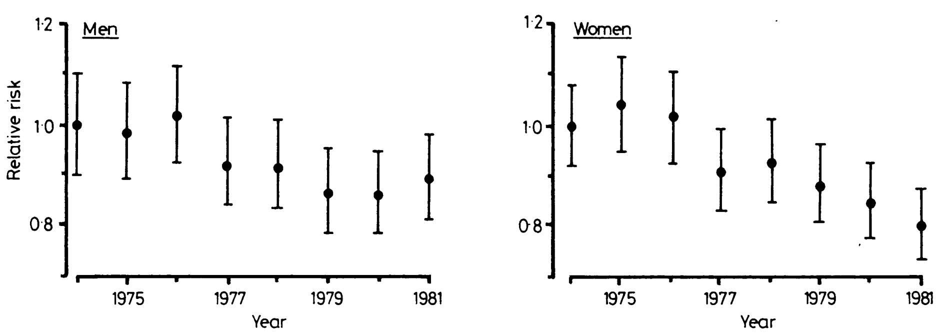

FIG 1—Mortality from stroke among men and women aged 40 and over. Relative risks in specific years according to the multiplicative model. Test of model for men: p=0·50; test of model for women: p=0·15.

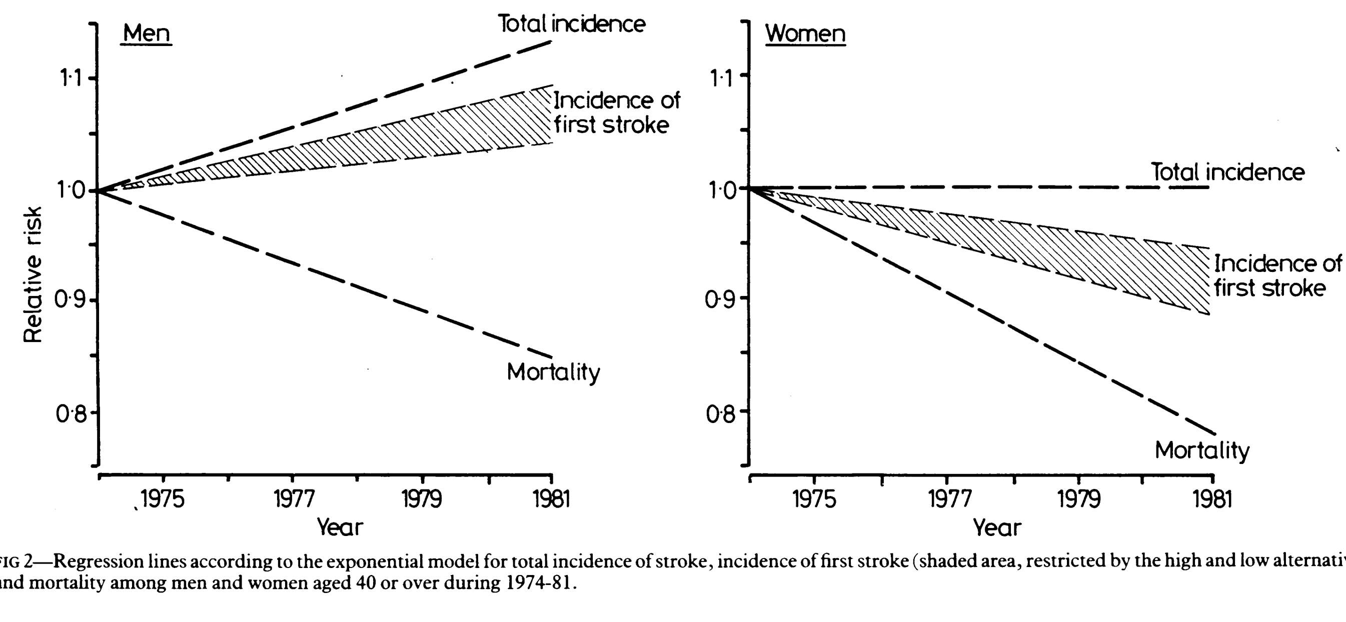

FIG 2—Regression lines according to the exponential model for total incidence of stroke, incidence of first stroke (shaded area, restricted by the high and low alternatives), and mortality among men and women aged 40 or over during 1974-81.

these values by making assumptions on both the incidence of stroke before 1974 and, for subjects who had suffered a stroke before 1974 (back to 1968), the risk of having a recurrent event of stroke in the future. The rationale for the assumptions was to choose two alternatives at each point of decision (based on our knowledge of the occurrence of strokes during 1974-81), one alternative that would probably result in an overestimation of the time trend of the incidence of first stroke during the years 1974-81 and another that would probably result in an underestimation of the trend.

Regarding the total incidence of stroke during 1968-73, for each age group we chose between the alternatives of absolute constancy (equal to the year 1974) and constancy of time trend so that the observed trend for 1974-81 could be extrapolated backwards. To calculate the number of cases of stroke for the years 1968-73 these age specific incidences were applied to the actual numbers of the population at risk for the relevant years. Then for each age group the expected number of subjects who had suffered a stroke was calculated for each of the years 1968-73 after having chosen and applied the corresponding proportional extremes (subjects/cases) from the years 1974-6. Finally, assumptions were made about the risk for these subjects of having recurrent events of stroke at different times in the future. These assumptions were taken as the corresponding extremes observed for subjects who had an initial diagnosis of stroke during any of the years 1974-6—that is, the extremes of γ_{ikl} for k=1974-6.

By applying these assumptions we were able to calculate the expected number of first strokes during the years 1974-81. We then estimated the high and low trend alternatives of the incidence of first strokes during 1974-81.

Although the purpose of this study was to elucidate time trends, we also calculated the observed magnitude of total incidence, incidence of first stroke, and mortality in 10 year age groups for 1981, the most recent year studied.

Results

Figure 1 shows the age standardised relative risk of dying from a stroke in any specific year according to the multiplicative model for men and women aged 40 and over. The year 1974 was used as reference and hence has the value 1·00. Confidence intervals of 95% are shown. For both men and women the mortality decreased appreciably. According to the exponential regression model the average annual decrease was 2·3% (95% confidence interval 1·3-3·3%) for men and 3·5% (2·5-4·4%) for women.

Tables II and III show age standardised relative risks of having a stroke in specific years according to the multiplicative model by sex and age. A substantially increased risk was observed in men aged 40-74. For women no consistent change could be observed during the study period.

Table IV shows the results of the trend analysis of the annual change in occurrence of stroke during 1974-81 according to the exponential regression model. Figure 2 shows the incidences of stroke during 1974-81 for men and women aged 40 and over according to the exponential model. Again the incidence in 1974 was used as a reference. The figure gives the total incidence of stroke as well as the incidence of first stroke and mortality. The shaded area indicates the incidence of first stroke. The borders of this area are the incidence of first stroke according to the high and low alternative, respectively. For men the incidence increased significantly during the study period with an average annual increase of roughly 1·8% (1·2-2·4%). The incidence of first stroke also showed an annual increase, though this value was smaller. For women the total incidence of stroke did not seem to change during the study, but there was an annual decline in the incidence of first stroke. As seen from the confidence intervals in table IV, the decline in the incidence of first stroke differed significantly from the more prominent decrease in mortality. Thus in women also the observed decrease in

TABLE II—*Incidence of stroke among men by age (relative risks in specific years according to the multiplicative model*)*

	Age group					
	40-74 years		≥75 years		>40 years	
	Relative risk†	95% Confidence intervals	Relative risk†	95% Confidence intervals	Relative risk†	95% Confidence intervals
1975	1·04	0·98-1·11	0·96	0·89-1·04	1·01	0·95-1·06
1976	1·17	1·10-1·24	1·01	0·94-1·09	1·10	1·04-1·16
1977	1·13	1·06-1·20	0·90	0·82-0·97	1·03	0·97-1·09
1978	1·18	1·11-1·25	0·92	0·85-1·00	1·07	1·01-1·13
1979	1·18	1·11-1·25	0·97	0·90-1·05	1·09	1·03-1·15
1980	1·17	1·10-1·24	0·99	0·92-1·07	1·09	1·03-1·16
1981	1·25	1·17-1·32	1·06	0·98-1·14	1·17	1·10-1·23
Annual average change (%)	2·6	1·8-3·3	0·7	−0·3-1·7	1·8	1·2-2·4

*Test of model: p=0·55 and p=0·5 for younger and older men, respectively.
†1974 was used as reference year.

TABLE III—*Incidence of stroke among women by age (relative risks in specific years according to the multiplicative model*)*

	Age group					
	40-74 years		≥75 years		>40 years	
	Relative risk†	95% Confidence intervals	Relative risk†	95% Confidence intervals	Relative risk†	95% Confidence intervals
1975	0·97	0·88-1·07	1·02	0·95-1·09	1·00	0·95-1·06
1976	1·02	0·93-1·12	0·99	0·93-1·06	1·00	0·95-1·06
1977	0·95	0·86-1·05	0·97	0·91-1·04	0·96	0·91-1·02
1978	0·98	0·89-1·08	0·98	0·92-1·05	0·98	0·93-1·04
1979	1·01	0·91-1·11	0·98	0·92-1·05	0·99	0·94-1·05
1980	0·96	0·87-1·06	0·99	0·93-1·06	0·98	0·93-1·04
1981	1·05	0·96-1·16	0·99	0·93-1·06	1·01	0·96-1·07
Annual average change (%)	0·4	−0·6-1·5	−0·2	−0·9-0·4	0·0	−0·6-0·6

*Test of model: p=0·005 and p=0·25 for younger and older women, respectively.
†1974 was used as reference year.

TABLE IV—*Average annual change (%) in occurrence of strokes for men and women aged 40 and over during 1974-81 (values in parentheses are 95% confidence intervals)*

	Men	Women
Mortality	−2·3 (−3·3-−1·3)	−3·5 (−4·4-−2·5)
Total incidence	1·8 (1·2-2·4)	0·0 (−0·6-0·6)
Incidence of first stroke:		
Low alternative	0·6 (−0·4-1·5)	−1·7 (−2·4-−1·1)
High alternative	1·3 (0·3-2·3)	−0·8 (−1·7-0·1)

mortality was not accompanied by a similar decrease in the total incidence of stroke or the incidence of first stroke.

There was an annual increase in the incidence of transient ischaemic attack (ICD 435) of 2·7% for men and 4·1% for women. Changes in the annual incidence of all cases of ischaemic and ill defined strokes (ICD 432, 433, 434, 436, 437, and 438) except transient ischaemic attack increased by 2·2% (1·5-2·9%) in men and 0·4% (−0·3-1·1%) in women. The annual incidence of haemorrhagic strokes (ICD 431) decreased significantly for both sexes. The decrease was 1·7% (0·1-3·2%) for men and 6·3% (4·7-7·8%) for women.

TABLE V—*Incidence and mortality from stroke/1000 person years in relation to age and sex in Stockholm in 1981*

Age (years)	Total incidence		Incidence of first stroke		Mortality	
	Men	Women	Men	Women	Men	Women
40-49	1·2	0·8	0·8	0·5	0·14	0·09
50-59	4·8	2·6	3·1	1·7	0·67	0·23
60-69	13·9	6·5	7·5	3·6	1·8	1·1
70-79	36·5	22·6	19·2	12·9	9·2	5·2
80-89	66·9	59·0	36·7	35·3	22·1	20·2
≥90	100·1	83·9	63·7	54·2	53·6	43·1
All ages over 40	13·0	11·8	7·2	7·1	3·0	3·2

Table V shows the total incidence, incidence of first stroke, and mortality during 1981, the most recent year studied. The increase in incidence and mortality from stroke with older age was evident.

Discussion

The decline in cerebrovascular mortality is well recognised in most industrialised countries,[4] and the trends in mortality in Stockholm are in accordance with this pattern. The decrease in mortality seen in this study, however, was not accompanied by a similar decrease in the incidence of strokes. An increased incidence of strokes has not yet been reported elsewhere, and studies of time trends in the incidence of strokes are comparatively few.[9-12]

This study is based on data obtained from the Swedish Cause of Death Register and from medical information systems. Patients admitted to hospital who are not registered on the Inpatient Care Register are reported to make up about 5% of all hospital admissions, only 3% of those admitted to departments of medicine, and less than 1% of those admitted to departments of neurology.[13] Of the total number of patients who suffer from a stroke, less than 10% are not admitted to hospital.[6 14] The number of patients not registered on the Inpatient Care Register and those not admitted to hospital seemed to be constant during our study. Throughout the study necropsies were performed on 48% of the patients, ranging from 54% in 1974 to 44% in 1981.

According to ICD rules, identical codes are used for first stroke, repeat stroke, and after stroke diagnoses, in contrast with the numbering system used for other diagnoses such as myocardial infarction. This may result in an overestimation of cases of stroke. The technique used in this study to compare years with each other and describe trends in incidences, however, reduces this error considerably. The trends in the incidence of first stroke are not affected by this potential error. In addition, the accuracy of the high and low alternatives of the time trend in the incidence of first stroke rests on these assumptions being made. The rationale for the assumptions was to choose two alternatives at each step in the process: one that would result in a probable overestimation of the time trend in the incidence of first stroke and another that would result in a probable underestimation of the trend. We therefore assumed that the true incidence of first stroke fell between these two alternatives.

Factors contributing to the obvious discrepancy between mortality and incidence, which was more noticeable among men than women, could be due to an increasing tendency during the study period for doctors to make a diagnosis of stroke or, more likely, an increasing alertness among people to seek medical care for symptoms caused by a stroke. Such a tendency among patients might be reflected in the observed increase in the incidence of transient ischaemic attack (ICD 435). Transient ischaemic attack made up 10% of all diagnoses of stroke. When transient ischaemic attack was excluded from the analysis the total incidence of stroke changed annually by 1·7% (95% confidence interval 1·1-2·3%) and −0·2% (−1·0-0·5%) for men and women, respectively. A decrease in the incidence of intracerebral haemorrhages and an increase in the incidence of ischaemic strokes is in accordance with the findings of other studies.[3] This change may in part be due to better diagnostic tools.[3] The shift in the subdiagnoses of strokes from haemorrhagic to ischaemic, however, does not explain the observed discrepancies in mortality and incidence for all stroke diagnoses together.

Special stroke units have not been shown to reduce mortality from stroke,[15-18] though improvement in neurological outcome has been shown.[16 19] Most patients in our study received no such special care, but improvements in the care of patients who have suffered strokes, especially in the care of patients with complications such as heart failure and infectious diseases, have probably occurred during the past decade in Stockholm. A consequence of a possible reduction in mortality would be an increase in the number of recurrent events of stroke, which in turn would affect the total incidence of stroke.

Improved care for different primary risk factors associated with stroke—for example, hypertension—has been proposed as the major reason for the declining mortality. This proposal is supported by several intervention studies showing that effective treatment of hypertension reduces cardiovascular complications, especially stroke.[20-24]

The declining incidence of intracerebral haemorrhage, seen in both sexes, may represent improved care of patients with hypertension. Although arterial hypertension is a risk factor for both intracerebral haemorrhage and atherosclerotic brain infarction, there was no decrease in the incidence of ischaemic strokes. This may reflect the fact that hypertension is more strongly related to haemorrhages than to infarction, which is supported by the results of other studies.[25] The aetiological factors are too complex to be explained by hypertension per se, and the treatment of blood pressure might even have an unfavourable effect on some patients who have had ischaemic strokes.

Another factor that may have contributed to the decline in the incidence of intracerebral haemorrhages could be an increasing use of computed tomography in the diagnosis of stroke. No exact figures are available, however, on its general use throughout the study period. Previous studies in Stockholm indicate that the use of computed tomography in the diagnosis of strokes varies between centres and with age at onset.[13 26]

Apart from hypertension, old age is a major risk factor for stroke (table V). Population projections for Sweden in the coming years (up to the year 2025) suggest a continuous shift of the age profile of the population with an increasing number of elderly people.[27] Table I shows that events of stroke increased by 26% over an eight year period. If the observed age adjusted time trends for the total incidence of stroke and incidence of first stroke, as well as for mortality from stroke, show the same pattern in the future this will have a great impact on the resources for health care, especially as in Sweden this group of patients consumes more resources in terms of hospital days than any other diagnostic group in departments of medicine.

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References

1 Nichols ES, Johansen HL. Implications of changing trends in cerebrovascular and ischemic heart diseases mortality. *Stroke* 1983;**14**:153-6.
2 Manton KG, Baum HM. CVD mortality, 1968-1978: observations and implications. *Stroke* 1984;15:451-7.

3 Garraway WM, Whisnant JP, Drury I. The changing pattern of survival following stroke. *Stroke* 1983;14:699-703.
4 Anonymous. Why has stroke mortality declined? [Editorial]. *Lancet* 1983;i:1195-6.
5 National Board of Health and Welfare. *International statistical classification of diseases, injuries and causes of death 1965 revision, adapted for indexing of hospital records and morbidity statistics*. 3rd ed. Stockholm: Liber, 1973.
6 Aho K, Harmsen P, Hatano S, Marquardsen J, Smirnov VE, Strasser T. On behalf of the participants in the WHO collaborative study on the control of stroke in the community. Cerebrovascular disease in the community. Results of a WHO collaborative study. *Bull WHO* 1980;58:113-30.
7 Ahlbom A. Acute myocardial infarction in Stockholm. A medical information system as an epidemiological tool. *Int J Epidemiol* 1978;7:271-6.
8 Breslow NE, Day NE. Indirect standardization and multiplicative models for rates, with reference to the age adjustment of cancer incidence and relative frequency data. *J Chronic Dis* 1975;20:239-303.
9 Harmsen, P, Berglund G, Larsson O, Tibblin G, Wilhelmsen L. Stroke registration in Göteborg, Sweden 1970-75. Incidence and fatality rates. *Acta Med Scand* 1979;206:337-44.
10 Garraway WM, Whisnant JP, Furlan AJ, Phillips LH, Kurland LT, O'Fallon WM. The declining incidence of stroke. *N Engl J Med* 1979;300:449-52.
11 Kotila M. Declining incidence and mortality of stroke? *Stroke* 1984;15:255-9.
12 Robins M, Baum HM. The national survey of stroke. Incidence. *Stroke* 1981;12(suppl 1):45-57.
13 Mettinger KL, Söderström CE, Allander E. Epidemiology of acute cerebrovascular disease before the age of 55 in Stockholm County 1973-77. I. Incidence and mortality rates. *Stroke* 1984;15:795-801.
14 Terént A. Acute cerebrovascular diseases. Uppsala: University Hospital, 1980. (Thesis.)
15 von Arbin M, Britton M, de Faire U, Helmers C, Miah K, Murray V. A study of stroke patients treated in a non-intensive stroke unit or in general medical wards. *Acta Med Scand* 1980;208:81-5.
16 Strand T, Asplund K, Eriksson S, Hägg E, Lithner F, Wester PO. A non-intensive stroke unit reduces functional disability and the need for long-term hospitalization. *Stroke* 1985;16:29-38.
17 Cooper SW, Olivet JA, Wollsey FM Jr. Establishment and operation of combined intensive care unit for patients with cardiac and cerebrovascular disease. *NY State J Med* 1972;72:2215.
18 Drake WE Jr, Hamilton MJ, Carlsson M, Blumenkrantz J. Acute stroke management and patient outcome, the value of neurovascular care units (NCU). *Stroke* 1974;4:933.
19 Hewer RL. Stroke units. *Br Med J* 1972;i:52.
20 Veterans Administration Cooperative Study Group on Antihypertensive Agents. Effects of treatment on morbidity in hypertension: results in patients with diastolic blood pressure averaging 115 through 129 mm Hg. *JAMA* 1967;202:1028-34.
21 Veterans Administration Cooperative Study Group on Antihypertensive Agents. Effects of treatment on morbidity in hypertension. II. Results in patients with diastolic blood pressure averaging 90 through 114 mm Hg. *JAMA* 1970;213:1143-52.
22 Helgeland A. Treatment of mild hypertension, a five year controlled drug trial: the Oslo study. *Am J Med* 1980;69:725-32.
23 Report by the Management Committee. The Australian therapeutic trial in mild hypertension. *Lancet* 1980;i:1261-7.
24 Hypertension Detection and Follow Up Program Cooperative Group. Five-year findings of the hypertension detection and follow-up program. III. Reduction in stroke incidence among persons with high blood pressure. *JAMA* 1982;247:633-8.
25 Black DG, Heagerty AM, Bing RF, Thurston H, Swales JD. Effects of treatment for hypertension on cerebral haemorrhage and infarction. *Br Med J* 1984;289:156-9.
26 Britton M, Hindmarsh T, Murray V, Tydén SA. Diagnostic errors discovered by CT in patients with suspected stroke. *Neurology* 1984;34:1504-7.
27 Central Bureau of Statistics. *Population projection for Sweden 1983-2025*. Stockholm: Liber, 1983.

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Mortality probability in victims of fire trauma: revised equation to include inhalation injury

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Abstract

There are no clear guidelines on the early diagnosis of injury due to inhalation of smoke. A clinical scoring system in the form of a previously prepared questionnaire may be used in the accident and emergency department by staff who are inexperienced in the management of inhalation injury. By quantifying injury due to smoke inhalation, its contribution to mortality in a large group of fire victims was established and a revised mortality probability equation derived using age, percentage surface area of the burn, and extent of inhalation injury.

This mortality probability equation may be used to divide patients into risk categories for early intensive care management and allows the comparison of mortality data between accident and emergency units receiving varying numbers of patients with injuries due to burns and smoke inhalation.

Introduction

The two most important advances in the management of patients suffering from burns—namely, early intravenous fluid resuscitation after the burn[1] and the introduction of effective topical chemotherapy, particularly the sulphonamides in the 1960s[2]—led to a revised analysis of mortality from burns by Bull in 1971.[3] He produced a probability chart based on probit analysis for age of patient and percentage of the body surface area burnt, and this has been used widely as a standard reference in assessing the mortality figures from burns units. There has, however, been a gradual increase in the number of casualties from fires in recent years, and over half of the resulting deaths may be expected to occur as a direct result of inhalation of smoke.[4 5] This is paralleled by an increasing use of synthetic polymers in household construction, furnishings, and decoration.[6]

In the regional burns unit at Glasgow Royal Infirmary mortality from burns has increased beyond that expected from Bull's mortality probability chart in parallel with an increase in the pulmonary complications in patients with concomitant injury due to smoke inhalation. We analysed the influence of smoke inhalation on mortality probability, quantified prospectively by a clinical data score plus estimation of carboxyhaemoglobin concentration, to see whether Bull's mortality probability chart underestimates the patients' risk of injury due to smoke inhalation in situations where fire trauma with concomitant smoke inhalation is common. The system of collecting clinical data was directed towards ease of use by the casualty officer without requiring previous experience of managing inhalation injury. The derived mortality probability equation was also intended to give an immediate estimate of risk using any simple calculator with a log function.

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Subjects and methods

SUBJECTS

For a consecutive period of 18 months all casualties from house fires requiring assessment and treatment at Glasgow Royal Infirmary for suspected smoke inhalation, with or without surface burns, were included in the study. The initial criterion for inclusion was either the complaint by the patient or, when the patient was unable to give a coherent history, a report by the attending firemen and ambulance crew that the patient was at risk from possible smoke inhalation.