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Chapter 2

Epidemiology of stroke in the Netherlands from 1972 to 1994: the end of the decline in stroke mortality

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ABSTRACT

In 1994, stroke was responsible for the death of 4,994 men and 7,601 women in the Netherlands, corresponding to 7.5% of all deaths in men and 11.4% in women. Age adjusted stroke mortality declined by 39% for men and by 45% for women between 1972 and 1994. However, the decline in mortality levelled off after 1987. In contrast to mortality, age adjusted discharge rates increased by 47% for men and by 28% for women during the study period. The decline in mortality was equally distributed over the age groups, while the increase in the number of hospital admissions was more pronounced in the older age groups. The analyses by diagnostic subgroups of stroke showed the importance of increasing diagnostic capabilities in the hospital setting. The use of diagnostic subgroups in national mortality data was of limited value, illustrated by the fact that 70% of all stroke deaths in 1994 belonged to the ill-defined type of stroke.

INTRODUCTION

Stroke is a major health problem. Not only is it the third leading cause of death in the industrialised world, but many survivors of stroke are left disabled.¹⁻³ Furthermore, the costs of illness are impressive. Between 3 and 4% of the health care budget in the Netherlands is utilised by stroke patients.^{4,5} Most countries experienced a decline in stroke mortality during recent decades.^{1,6,7} However, several countries have recently reported the end of the decline in stroke mortality or even a rise in stroke incidence.⁸⁻¹⁴ With opposing trends being observed in different countries it is important to monitor stroke in the population. We studied trends in the number of deaths and hospital discharges due to stroke from 1972 to 1994 in the Netherlands by age, sex and type of stroke.

METHODS

We obtained population figures and the number of deaths from stroke in the Netherlands for the period 1972-1994 from Statistics Netherlands.¹⁵ All death certificates in the Netherlands are filled in by treating physicians and then sent to Statistics Netherlands for coding and recording in the central database. Mortality data were grouped by 5-year age groups, sex and underlying cause of death. From 1972 up to 1978, the 8th version of the *International Classification of Diseases* (ICD) was used. Thereafter, coding was according to the 9th ICD version. We used rubrics 430-438 in both the ICD-8 and ICD-9 version to indicate stroke. For mortality, we divided stroke into 4 different types: subarachnoid haemorrhage (430 in both ICD-8 and ICD-9), haemorrhagic stroke (431 in ICD-8 and 431-432 in ICD-9), thrombo-embolic stroke (432-434 in ICD-8 and 433-434 in ICD-9) and ill-defined stroke (435-438 in both ICD-8 and ICD-9).

The number of hospitalisations for stroke was derived from the central database for hospital admissions in the Netherlands named the National Medical Register and maintained by SIG Health Care Information. In 1972, the start-up year of our analysis, 70% of all hospital admissions in the Netherlands was recorded in this database. In 1977, the coverage had grown to 90%, in 1982 to 97%, and coverage was complete from 1986 onwards. These overall ratios were used to estimate the yearly number of hospital admissions for stroke in the Netherlands. Records contain diagnosis at discharge, age and gender of the patient, length of stay and status at discharge (dead or alive). Only admissions with a first-listed (primary) discharge diagnosis of stroke were included. All discharge diagnoses were coded according to the *International*

Classification of Diseases, Clinical Modification (ICD-CM). The change from ICD-CM-8 to ICD-CM-9 occurred in 1980. The same types of stroke were analysed, except that transient cerebral ischaemia (ICD-CM code 435 in both ICD-8 and ICD-9) was analysed separately.

In-hospital case fatality ratios (as a percentage) were calculated by dividing the number of admissions for stroke with discharge status dead by the total number of discharges for stroke. To calculate the average age at death or admission, we assumed that all persons died or were admitted, on average, at the mid-point of each 5 year age category. Mid-year populations were calculated by averaging the population number at the beginning and end of each year. Age adjusted discharge and mortality rates were calculated by direct standardisation to the European Standard Population, with equal weighting schemes for men and women.¹⁶ Annual percentage changes in mortality and discharge rates were estimated using Poisson regression.¹⁷ The number of discharges or deaths were used as response variables, with mid-year population figures as person-years. Calendar year (continuous) and 5 year age groups (categorical) were used as explanatory variables. For the trend in mortality from stroke, 1987 was chosen as the cut off point because of the distinct change in trend on visual inspection of the data.

RESULTS

Mortality

Stroke was responsible for the death of 4,994 men and 7,601 women in 1994 (table 1), corresponding to 7.5% of all deaths in men and 11.4% in women. 62% of all stroke deaths in men occurred after the age of 75, with an average age at death of 76.4 years in 1994 (table 1). For women these figures were 82% and 81.8 years, respectively.

In the period 1972-1994, the age adjusted death rate dropped by 39% for men and by 45% for women (figure 1). Analysis of age-specific death rates revealed that there was a fairly even contribution of the most relevant age groups to this decline (figure 2). However, this decline levelled off around 1987 for both men and women. From 1972 to 1986, the annual percentage change in age adjusted mortality was -2.7% in men (95% confidence interval (CI) -2.8% to -2.5%) and -3.4% in women (95% CI -3.6% to -3.2%). From 1987 onwards the annual change was -0.9% in men (95% CI -1.3% to -0.4%) and -0.5% in women (95% CI -0.9% to -0.1%).

Table 1. Number of deaths, mean age at death, number of hospital discharges and mean age at admission for stroke in the Netherlands for the years 1972, 1977, 1982, 1987, 1992 and 1994.

Year	Deaths		Mean age at death (in years)		Hospital discharges		Mean age at admission (in years)	
	Men	Women	Men	Women	Men	Women	Men	Women
1972	5,985	7,066	75.3	77.7	7,750	7,129	65.5	68.5
1977	5,316	6,473	75.5	77.9	10,343	9,390	66.5	69.1
1982	5,182	6,946	76.1	79.5	12,666	11,636	67.1	70.3
1987	4,771	6,806	76.8	80.8	13,406	12,854	67.7	71.5
1992	5,000	7,926	76.9	81.4	13,740	13,655	67.6	71.2
1994	4,994	7,601	76.4	81.8	15,296	14,098	67.8	71.3

Source: Statistics Netherlands and SIG Health Care Information.

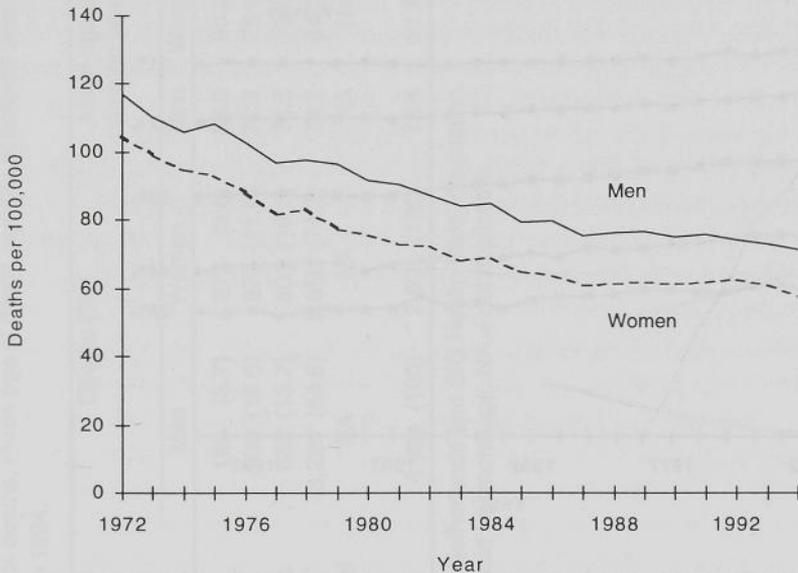


Figure 1. Age adjusted death rates from stroke for men and women in the Netherlands from 1972 to 1994. Direct standardisation to the European standard population.¹⁶

Source: Statistics Netherlands.

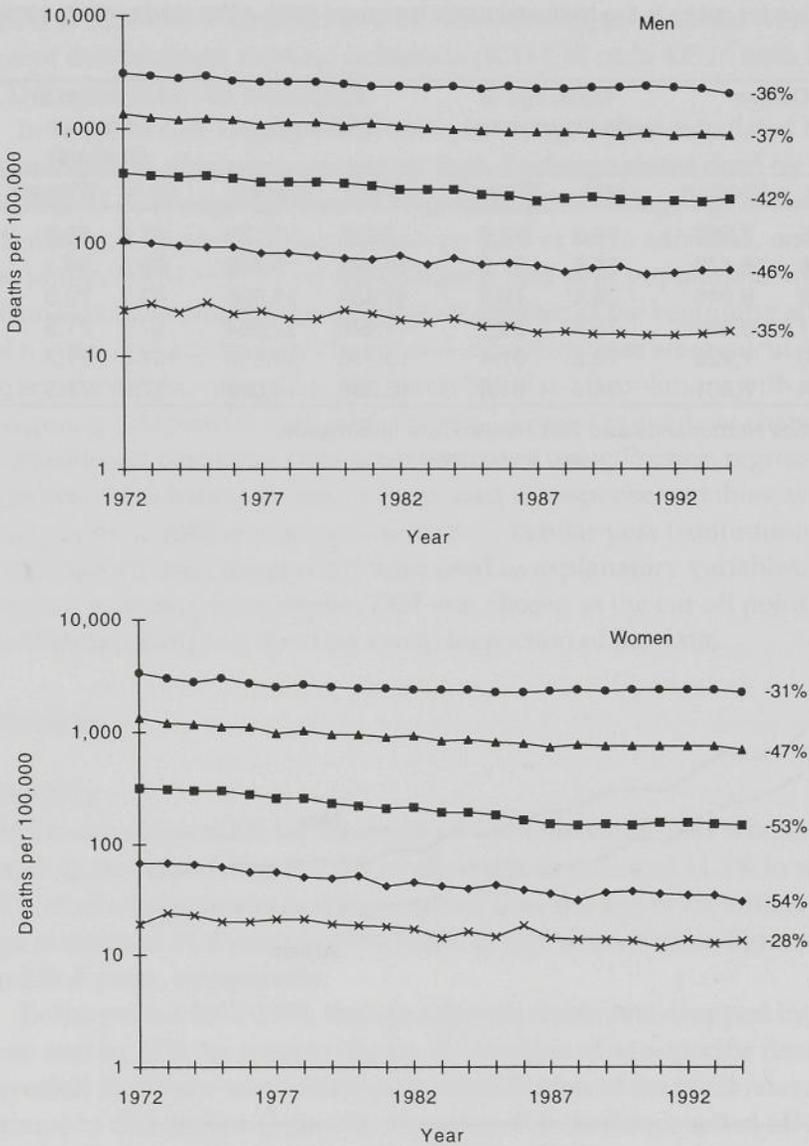


Figure 2. Age-specific death rates from stroke for men (upper panel) and women (lower panel) in the Netherlands from 1972 to 1994. In the sideline, the overall percentage change from 1972 to 1994 is given. Age groups in years: x=45-54, ◆=55-64, ■=65-74, ▲=75-84, ●=85 and over. Source: Statistics Netherlands.

Table 2. Number of deaths, mean age at death, number of hospital discharges and mean age at admission by type of stroke and sex in the Netherlands in 1994.

Type of stroke	Deaths (%)		Mean age at death (in years)		Hospital discharges (%)		Mean age at admission (in years)	
	Men	Women	Men	Women	Men	Women	Men	Women
	SAH	186 (3.7)	272 (3.6)	56.0	60.2	538 (3.5)	842 (6.0)	55.4
Haemorrhagic	900 (18.0)	878 (11.6)	71.9	75.9	2,327 (15.2)	1,977 (14.0)	68.1	71.0
Thrombo-embolic	682 (13.7)	801 (10.5)	74.5	79.6	6,395 (41.8)	5,180 (36.7)	67.8	72.1
Ill-defined	3,226 (64.6)	5,650 (74.3)	79.2	84.1	3,987 (26.1)	4,338 (30.8)	69.5	73.4
Transient cerebral ischaemia	NA	NA	NA	NA	2,049 (13.4)	1,761 (12.5)	67.2	71.1
All stroke	4,994 (100)	7,601 (100)	76.4	81.8	15,296 (100)	14,098 (100)	67.8	71.3

Source: Statistics Netherlands and SIG Health Care Information.
 SAH = Subarachnoid haemorrhage, NA = not applicable.

The analysis by type of stroke revealed that 65% of all stroke deaths in men in 1994 belonged to the ill-defined group of stroke and 74% in women (table 2). The mean age at death in 1994 for the 4 types of stroke is given in table 2. For all types of stroke, the mean age at death was higher in women than in men. The youngest age at death was noted for subarachnoid haemorrhage, and the oldest was for the ill-defined type of stroke. During the study period, the age adjusted death rate in men for subarachnoid haemorrhage declined by 42%, for thrombo-embolic stroke by 50%, for haemorrhagic stroke by 24% and for the ill-defined group by 40%. For women, these figures were 22%, 61%, 47% and 41%, respectively.

Hospital discharges

The number of hospital discharges for stroke and the average age at admission are given in table 1. In 1994, stroke was responsible for 1.8% of all hospital discharges in the Netherlands, and for 4.3% of all days of hospitalisation. From 1972 until 1986, there was a steady increase in the age adjusted discharge rates for stroke. Thereafter, the rate was more or less stable (figure 3).

The rate of hospitalisation in all age groups above the age of 45 years was higher in men than in women. For the entire study period, there was a 47% increase in age adjusted discharge rates for men, and a 28% increase for women. All relevant age groups contributed to this increase, but the rise was more marked in the older age groups. The annual percentage increases for men by age group were 0.1% (45-54 years), 0.9% (55-64 years), 1.4% (65-74 years), 1.7% (75-84 years) and 2.1% (85 years and over). For women, these annual changes were 0.5% (45-54 years), 0.6% (55-64 years), 0.3% (65-74 years), 1.0% (75-84 years) and 1.9% (85 years and over). All tests for trend were significant at the 5% level, except for men aged 45-54 years and women aged 65-74 years.

During the study period, there was a steady decline in the length of hospitalisation for stroke. In 1972, the average length of stay was 29.6 days for men and 37.5 days for women. By 1994 these figures had declined to 20.1 and 25.5 days, respectively.

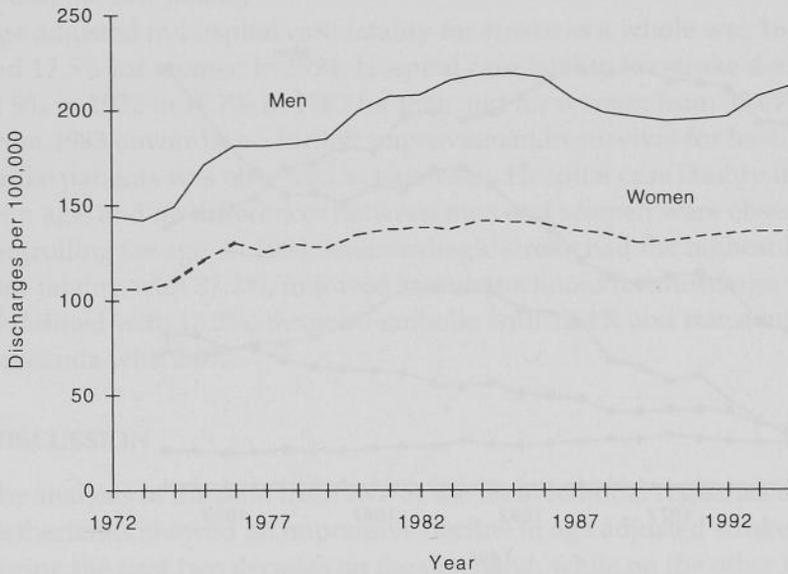


Figure 3. Age adjusted discharge rates for stroke in the Netherlands from 1972 to 1994 for men and women. Direct standardisation to the European standard population.¹⁶
Source: National Medical Register of SIG Health Care Information.

In 1994, thrombo-embolic stroke was the most frequent of the 5 types of stroke, responsible for 39% of all stroke discharges (table 2). Over time, different trends were observed for the 5 types of stroke (figure 4). From 1980 onwards, the age adjusted discharge rates for ill-defined stroke declined steadily during the remaining study period, resulting in an overall decline of 29% for men and 33% for women. For both haemorrhagic and thrombo-embolic stroke, the age adjusted discharge rates increased steadily over time. Overall, the age adjusted discharge rates more than doubled for both haemorrhagic stroke and thrombo-embolic stroke (figure 4). For the group of transient cerebral ischaemia, an initial steep increase was followed by a decline. The transition from increase to decline occurred around 1986. For the entire study period the discharge rates for transient cerebral ischaemia increased more than 3-fold. For subarachnoid haemorrhage, the trend for men and women was different. In men, there was a 26% decline in age adjusted discharge rate, while women experienced an increase of 12%.

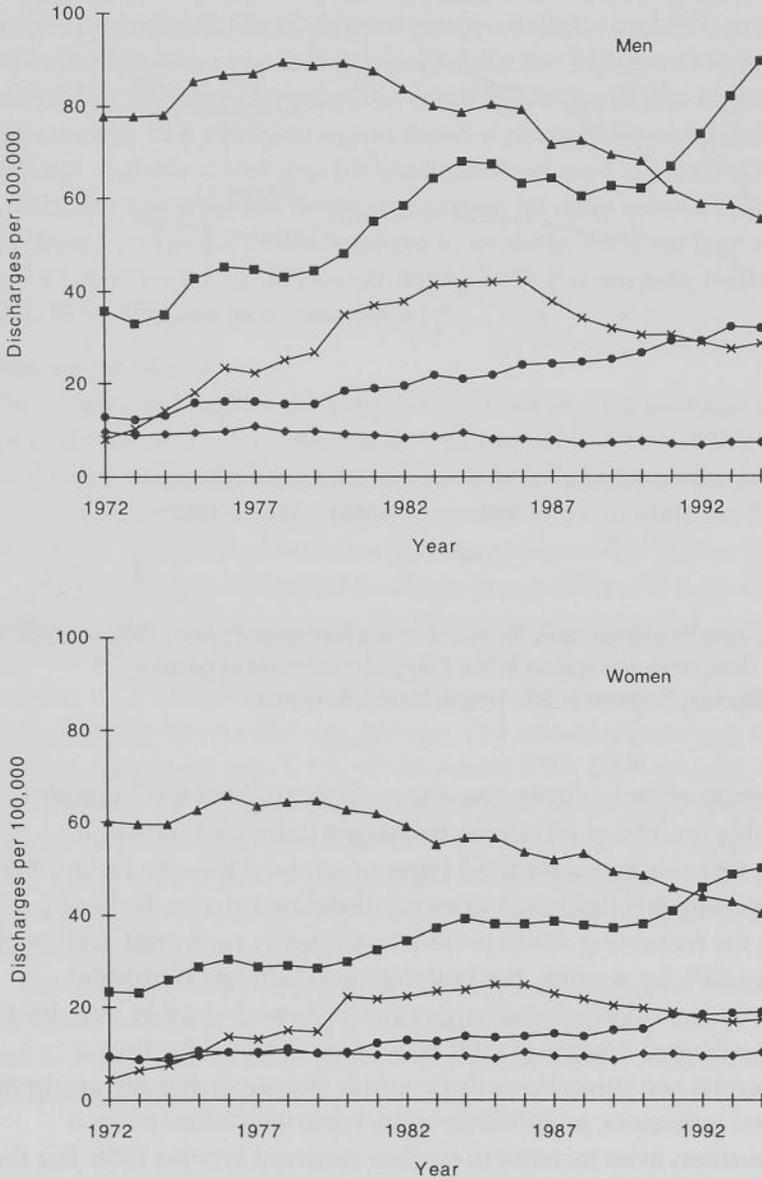


Figure 4. Age adjusted discharge rates for five different types of stroke for men (upper panel) and women (lower panel) in the Netherlands from 1972 to 1994. ♦=subarachnoid haemorrhage, ●=haemorrhagic, ■=thrombo-embolic, ▲=ill-defined, x=transient cerebral ischaemia. Direct standardisation to the European standard population.¹⁶

Source: National Medical Register of SIG Health Care Information.

In-hospital case fatality

Age adjusted in-hospital case fatality for stroke as a whole was 16.7% for men and 17.5% for women in 1994. Hospital case fatality for stroke decreased from 31.9% in 1972 to 17.7% in 1983 for men and for women from 33.6% to 19.6%. From 1983 onwards, no further improvement in survival for hospitalised stroke patients was observed in either sex. Hospital case fatality increased with age, and no differences between men and women were observed after controlling for age. In 1994, haemorrhagic stroke had the highest in-hospital case fatality with 37.2%, followed by subarachnoid haemorrhage with 27.2%, ill-defined with 18.2%, thrombo-embolic with 12.4% and transient cerebral ischaemia with 2.0%.

DISCUSSION

The analysis of the data from two of the main national registries in the Netherlands showed an impressive decline in age adjusted stroke mortality during the past two decades on the one hand, while on the other hand, age adjusted morbidity, as measured by hospital discharges, simultaneously rose. The decline in stroke mortality, however, levelled off after 1987. Before exploring some of the possible mechanisms that could explain these findings, we compare our results with data from other countries.

Mortality from stroke in the Netherlands has always been among the lowest in Western countries and was comparable with the level in Sweden, France, Canada and the United States.^{1,6} However, with the slow-down in the decline of stroke mortality in the Netherlands around 1987, the Netherlands now exceeds countries such as France, Switzerland and Canada in which the decline in stroke mortality has continued. Countries that have also reported a slow-down in the decline of stroke mortality are the United States and several Scandinavian countries.^{8,18}

The decline in stroke mortality

The impressive decline in age adjusted stroke mortality is likely to have been driven by a decline in stroke incidence. Several favourable changes in life-style could have contributed to this decline, and to the simultaneous decline in coronary heart disease incidence, such as a decline in smoking (especially in men), increasing awareness and treatment of hypertension and favourable changes in diet.^{19,20} Unfortunately, there are no long term studies measuring the incidence of stroke in the Netherlands that could support such possibilities. The limited number of studies in different settings that have measured stroke incidence in the Netherlands did not show a trend, upward or

downward, in stroke incidence during the past decade.^{3,21,22} In addition to a possible decline in stroke incidence, an improvement in survival after stroke may have been an additional factor in lowering stroke mortality. This hypothesis is supported by the decline in hospital case fatality which coincided with the decline in total mortality, although the lower hospital case fatality may partly be biased by a shorter length of stay for stroke patients over time. Factors that could have contributed to the lower hospital case fatality are more admissions for milder strokes and transient ischaemic attacks.^{23,24} Improvement in the management of stroke could also have lowered mortality. During the last two decades, no effective, new therapies for stroke have been developed. Most progress must have come from the prevention and treatment of complications of stroke. This concept is supported by the reported beneficial effect of treatment in stroke units.²⁵ Therapeutic measures that may have contributed are a more aggressive approach to volume depletion, better diagnostic tools that can help in focusing on specific treatments, early rehabilitation, prevention of deep venous thrombosis, and the use of secondary prevention with antiplatelet agents soon after stroke onset. The (recent) end of the decline in stroke mortality has been linked by others to the longer survival of patients with ischaemic heart disease, leading to a growing pool of patients at high risk for subsequent vascular events, including stroke.²⁶⁻²⁸

Increase in hospital discharges

There is a striking difference between the decline in mortality and the increase in age adjusted discharge rates. While the decline in mortality was similar across all relevant age groups, the rise in discharge rates was more prominent in the older age groups. The most likely explanation for this rise is an increase in the proportion of all stroke patients admitted to the hospital. This probably reflects the changing attitude of doctors towards stroke treatment and changes in society leading to fewer possibilities of giving adequate care to stroke patients at home. Growing knowledge of the pathophysiology, treatment and prevention of complications of stroke and the introduction of new diagnostic methods (e.g. computed tomography and magnetic resonance imaging) increased the doctors' awareness of stroke and may have changed their attitude to a more active approach, especially in the elderly.^{13,29} Whether an increase in the number of patients with recurrent stroke, as a result of the possible longer survival after stroke, is an additional factor that remains uncertain. The central database of hospital admissions in the Netherlands

lacks a unique patient identification number to identify re-admissions for stroke.

Validity of the study

This was a descriptive study, investigating only temporal relationships in vital statistics data. The main source of error in the use of vital statistics data lies in the determination and classification of the cause of death.^{30,31} Especially, in the case of older patients with multiple diseases, determining the primary cause of death is prone to inter-doctor variation. For stroke as a whole, some reassuring figures have come from the MONICA project. In their validation studies, reasonable agreement was found between the number of deaths from stroke, determined by strict guidelines, and those derived from official vital statistics data.³² However, no Dutch population is included in the MONICA project.

Hospital data are limited in that not all stroke patients are hospitalised and that readmissions cannot be identified. The first limitation is probably the most important one, because a large proportion of stroke patients is managed outside the hospital in the Netherlands. There is a lively debate in the Netherlands and other countries, whether stroke patients should be admitted to hospital.^{33,34} Recent estimates of the proportion of stroke patients treated outside the hospital in the Netherlands varied between 15 and 50%.^{3,35-38} For a reliable estimate of the incidence of stroke in the Netherlands, other studies are needed in which both hospitalised and non-hospitalised patients are taken into account.^{13,26,39,40} Data on the accuracy of hospital discharge abstracts for stroke are scarce, although the determination of primary discharge diagnosis on hospital data should be easier than establishing the cause of death outside the hospital.⁴¹⁻⁴³

These limitations apply to all studies using this type of data sources. There are also some specific advantages to the Dutch registry of hospital admissions. Firstly, there are no private hospitals in the Dutch health care system for patients with cerebrovascular diseases. Secondly, all hospitals (university and general) have participated in this register since 1986, thereby avoiding sampling bias. All relevant data from the hospitals are stored in a central database and uniform guidelines for the coding process are enforced in the hospitals by a permanent process of training of specialised personnel. Before 1986, there was a partial, but still high, coverage.

Division by type of stroke

We used a division similar to Modan's and Wagener⁴⁴ except that we analysed transient cerebral ischaemia as a separate group. Transient cerebral ischaemia was among the ill-defined group in their paper. A similar approach, for

mortality data alone, has been used by Baum and Goldstein.⁴⁵ For mortality in the Netherlands, the division by type of stroke resulted in a large proportion (70%) of ill-defined strokes, with a notable difference between men and women (65% in men *vs.* 74% in women). Data from the United States showed that around 60% of all stroke deaths were classified as ill-defined.⁴⁴ Of all stroke deaths in the Netherlands occurring within a hospital, 55% had an ill-defined type of stroke as the cause of death compared with 86% of all stroke deaths occurring outside the hospital. This reflects the difficulty of determining a specific type of stroke as the cause of death outside the hospital. This is in accord with the fact that from physical signs alone it is difficult to distinguish between haemorrhagic and thrombo-embolic stroke, even in a hospital setting.^{46,47} Therefore, the construction of diagnostic subgroups for total mortality is of little value given the fact that about 50% of all stroke deaths in the Netherlands occurred outside the hospital.

In 1994, the percentage of ill-defined stroke among the hospital discharges for stroke was 28%, which was higher than we expected. A recent study in several hospitals in the Netherlands revealed that in 93% of the stroke patients admitted to the hospital, a computed tomogram of the brain was performed.⁴⁸ These observations suggest that there is quite a substantial loss of diagnostic information during the coding process. From 1980, there was a steady decline in the ill-defined group of stroke, which probably reflects the improved diagnostic capabilities through computed tomography. A part of this decline is probably transferred to the thrombo-embolic and haemorrhagic types of stroke. This is probably one of the main reasons behind the steady increase in these types of stroke (figure 4).

In conclusion, from 1972 to 1994, age adjusted stroke mortality in the Netherlands was nearly halved. There are indications of both a decline in stroke incidence and in case fatality of stroke. However, since 1987 the decline in stroke mortality has levelled off. The use of diagnostic subgroups of stroke in the case of total mortality was of little value given the limitations in determining the type of stroke in patients dying outside the hospital. For a better interpretation of hospital statistics data, more studies are needed on how all the diagnostic information is used in the coding process. New efforts in both the primary prevention of stroke and in optimisation of the treatment of stroke patients are needed to offset the expected increase in stroke patients due to ageing of the population.⁴⁹

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